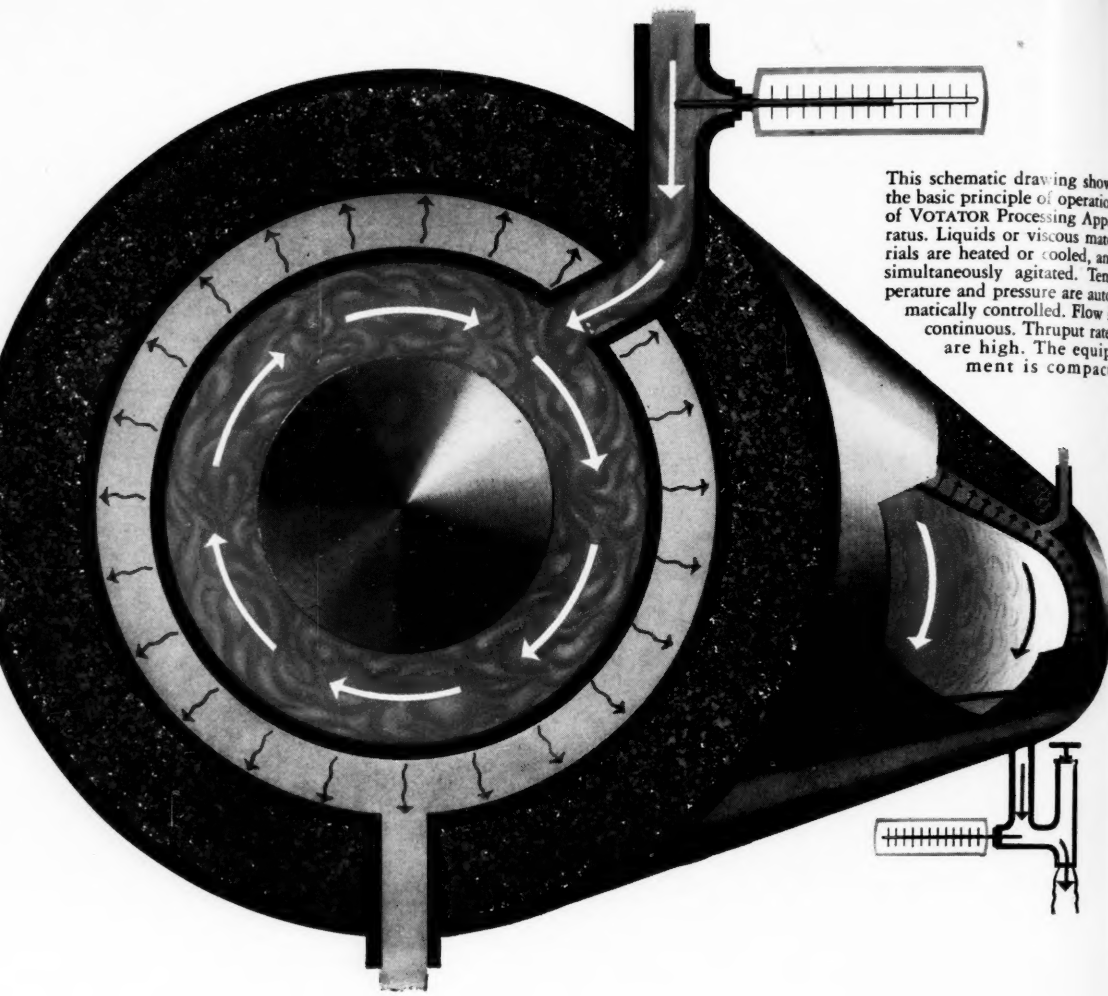
Chemical Engineering

A McGRAW-HILL PUBLICATION
ONE DOLLAR

MARCH 1957

HIGH TEMPERATURE FRONTIERS

THE OUTLOOK FOR MATERIALS AND PROCESSES



This schematic drawing shows the basic principle of operation of VOTATOR Processing Apparatus. Liquids or viscous materials are heated or cooled, and simultaneously agitated. Temperature and pressure are automatically controlled. Flow is continuous. Thruput rates are high. The equipment is compact.

This is continuous processing...

a proven way to increase profits

A host of chemical and food products are being made better and at lower cost with VOTATOR* Continuous Processing Apparatus. This heat-transfer equipment agitates and simultaneously heats or cools liquid or viscous materials. Its output rate is six to ten times that of conventional batch methods. The system is completely enclosed for absolute product cleanliness. Flow is continuous, automatically controlled for highest quality at all times.

Girdler engineers will gladly analyze your processing to show you specifically how VOTATOR Processing Apparatus can improve your product and lower your costs. Call us today.

*VOTATOR—Trade-Mark Reg. U.S. Pat. Off.

the GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

VOTATOR DIVISION: New York • Atlanta • Chicago • San Francisco

MARCH 1957

JOHN R. CALLAHAM, Editor-in-Chief

Does This Job Interest You?

Do you like to organize and interpret facts? To exchange ideas with other engineers? To teach, to explain, to pass along useful information?

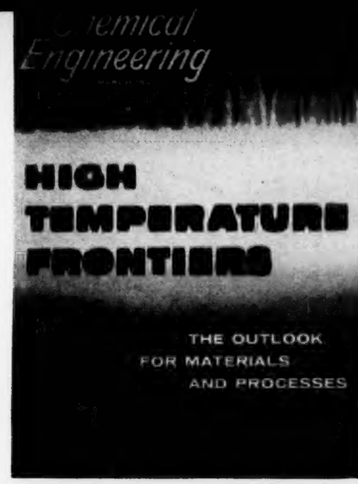
To keep closely in touch with what's going on in chemical engineering and in the chemical industries? To see the broad picture?

If so, here may be just the job you're looking for. CE now has an opening for a young editor to develop, evaluate and edit engineering articles.

Here're the qualifications:

- ▶ **Background:** Recent degree in chemical engineering, with sound training in fundamentals. One to four years of industry experience.
- ▶ **Abilities:** Able to analyze technical information accurately, to organize it logically and to explain it clearly. Inquisitive and open-minded; personal drive; able to work with a closely-knit team.
- ▶ **Environment:** New York City, with some out-of-town travel. As an assistant editor on CE's staff of 17 engineer-editors. In McGraw-Hill, a growth company with 34 magazines and over 400 editors.
- ▶ **Compensations:** Salary comparable to that in industry. Liberal personnel policies and benefits. Chance to grow within company. Unusual opportunity to broaden experience, education and contacts.

If you have "editorial" leanings, a recent degree, and if this summary appeals to you not merely as a job but as a way of life, write now (including all pertinent facts) to John R. Callaham, Editor.



GUIDED TOUR

The new frontier of chemical processing at better than 2,500 F.

Chemical process industry requirements for high-temperature materials are getting a big boost from current work on jets and missiles. Our report brings you up-to-date on progress. It considers methods, materials and processes—past, present and future (p. 237).

Market spurs Achromycin processing

By breeding harder-working microbes and streamlining a semi-continuous process, Lederle aims to hold its lead in the hot chase for tetracycline's (Achromycin's) booming market (p. 228).

Now—to cool it down

From the technology and possibilities of high temperatures (above), we go to cool-

GUIDED TOUR

ing. The reported experience with one type of problem will help you in designing better heat-transfer systems (p. 253).

Chemical engineering abstracts

All engineers—whether in development, design or production—will profit from our new series. Its annotated references will be a sure guide to fast help with equipment and process problems (p. 257).

What about equipment prices?

Annual survey of equipment costs confirms what you already know—all prices are up. Our indexes show you how much. They also give a basis for comparison with other industries (p. 266).

Your chance to nominate a winner

A distinguished committee of judges wants your help in picking the company that's done the most during the past three years to advance our profession. Whom do you nominate for the award? (p. 268).

To keep pace with development, design, production and technical management in the chemical process industries, more engineers subscribe to CE than to any other magazine in the field. Paid circulation of this issue:

42,403

Chemical

MARCH 1957

Developments in Chemical Engineering

Practice of Chemical Engineering

Engineering

Vol. 64, No. 3

CE REFRESHER

PLANT NOTEBOOK

CORROSION FORUM

People in Chemical Engineering

YOU AND YOUR JOB

Reader Service

Publisher .... Wallace F. Traendly
Editorial Director .... Sidney D. Kirkpatrick
Editor-in-Chief .... John R. Callaham

Engineering Developments

Editor .... Cecil H. Chilton
Assistant Editors: Frances Arne, Donald R. Cannon, T. Peter Forbath, Mary A. Gibbons. Editorial Assistant: John B. Bacon. Economics Consultant: William H. Chartener.

Engineering Practice

Editor .... Theodore R. Olive
Associate Editors: Calvin S. Cronan, Raymond F. Fremed, Robert B. Norden. Assistant Editor: Steven Danatos.

Presentation & Production

Editor .... Lester B. Pope
Art Editor: Margaret R. Wenk. Art Assistant: Margi Paul. Editorial Makeup: Carol A. Nelson. Reprints: Elaine G. Garbett.

Regional Editors

Midwest (Chicago): Frank C. Byrnes. Western (San Francisco): Elliot Schrier. Southwest (Houston): James A. Lee. Washington Manager: G. B. Bryant, Jr. Representatives in 73 U.S. cities and 60 foreign countries.

Advertising & Circulation

Advertising Sales Manager .... Steven J. Shaw
Circulation Manager .... Paul W. Erb
Business Manager: Anton J. Mangold. Promotion Manager: Hugh T. Sharp. Market Service: J. Paschall. Reader Service: C. J. Rohrbach. Advertising Makeup: Grace Barrie. Sales Representatives: See p. 472.

Chemical Engineering (with Chemical & Metallurgical Engineering) is published monthly with an additional issue in Mid-September by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. Publication Office: 99-129 North Broadway, Albany 1, N. Y.

▶ **Executive, Editorial and Advertising:** 330 West 42nd St., New York 36, N. Y. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice President and Treasurer; John J. Cooke, Secretary; Nelson Bond, Executive Vice President, Publications Division; Ralph B. Smith, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator.

▶ **Subscriptions:** Write to Chemical Engineering—Subscription Service, 330 West 42nd St., New York 36, N. Y. Allow one month for change of address. Please show position and company connection on all orders.

Single copies $1 in U. S., possessions and Canada; $2 in all other countries. U. S. and possessions, $3 per year, $4 for two years, $5 for three years; Canada, $4 per year, $6 for two years, $8 for three years; other Western Hemisphere and the Philippines, $15 per year, $25 for two years, $30 for three years; all others: $25 per year, $40 for two years, $50 for three years.

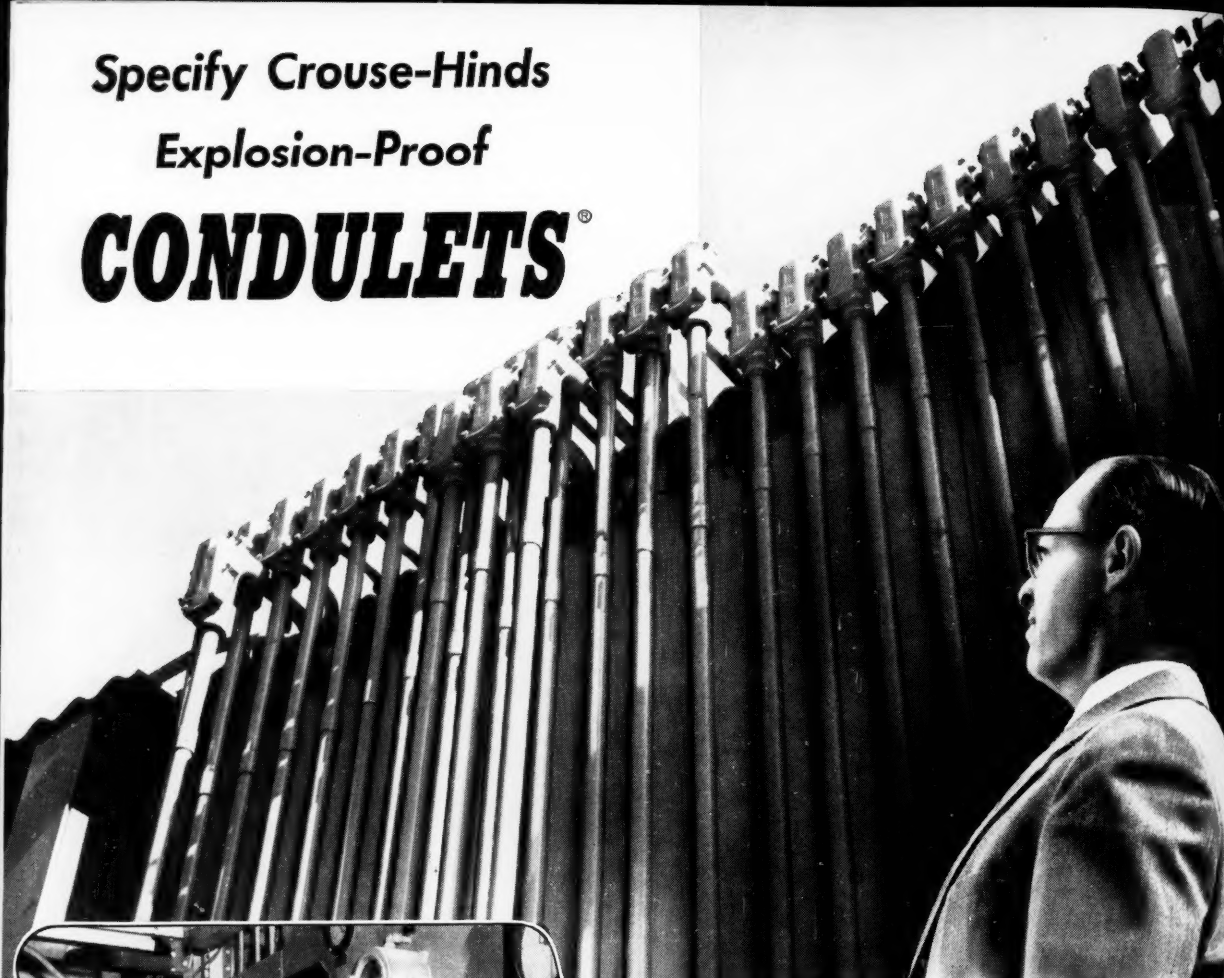
Second class mail privileges authorized at Albany, N. Y. Printed in U.S.A. Member A.B.P. Member A.B.C.

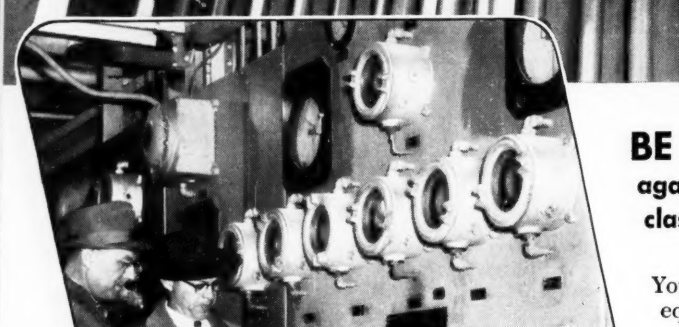
Chemical Engineering

Developments

MARCH 1957

Department Index





Chementator

C. H. CHILTON

√ **Air Reduction has five engineers in Japan scrutinizing an unidentified process which Airco President Hill thinks "is going to look good." Best bet: synthetic fiber made from polyvinyl alcohol.**

√ **Pitt-Consol's plans for disposal of tar from its projected low-temperature coal carbonization plant at Cresap, W. Va., now include production of furnace-type carbon black. This would be a joint venture with one or more partners and would be first U. S. production of furnace black in the Northeast.**

√ **Reduction of 20% in capital cost is claimed for a new contact sulfuric acid process developed in Europe. Plant operates under vacuum created by its turbine-type absorber.**

Portable cracking plant for acetylene

Research and engineering work on acetylene via thermal cracking of liquid hydrocarbons has taken a new tack—development of a portable acetylene plant which uses jet fuel as raw material.

Institute of Gas Technology, Chicago, has completed basic process research and is now building a 500-scf./hr. prototype unit adaptable to trailer mounting. This project, like Girdler's parallel development of a portable hydrogen plant (see pp. 148-9), is sponsored by the Army Corps of Engineers.

Process operates at 2,800 F. and ½ atm. in the presence of superheated steam. Subsequent purification produces a stream of 95% acetylene.

Portable units will provide acetylene for field welding and cutting in forward military areas. Readily available raw material will eliminate need for handling of calcium carbide, with its difficult and hazardous logistic problems.

Fluid bed reactivates spent carbon

Fluid-bed revivification of granular activated carbon is due for its first commercial-scale tryout late this year at Corn Products' Kansas City dextrose plant.

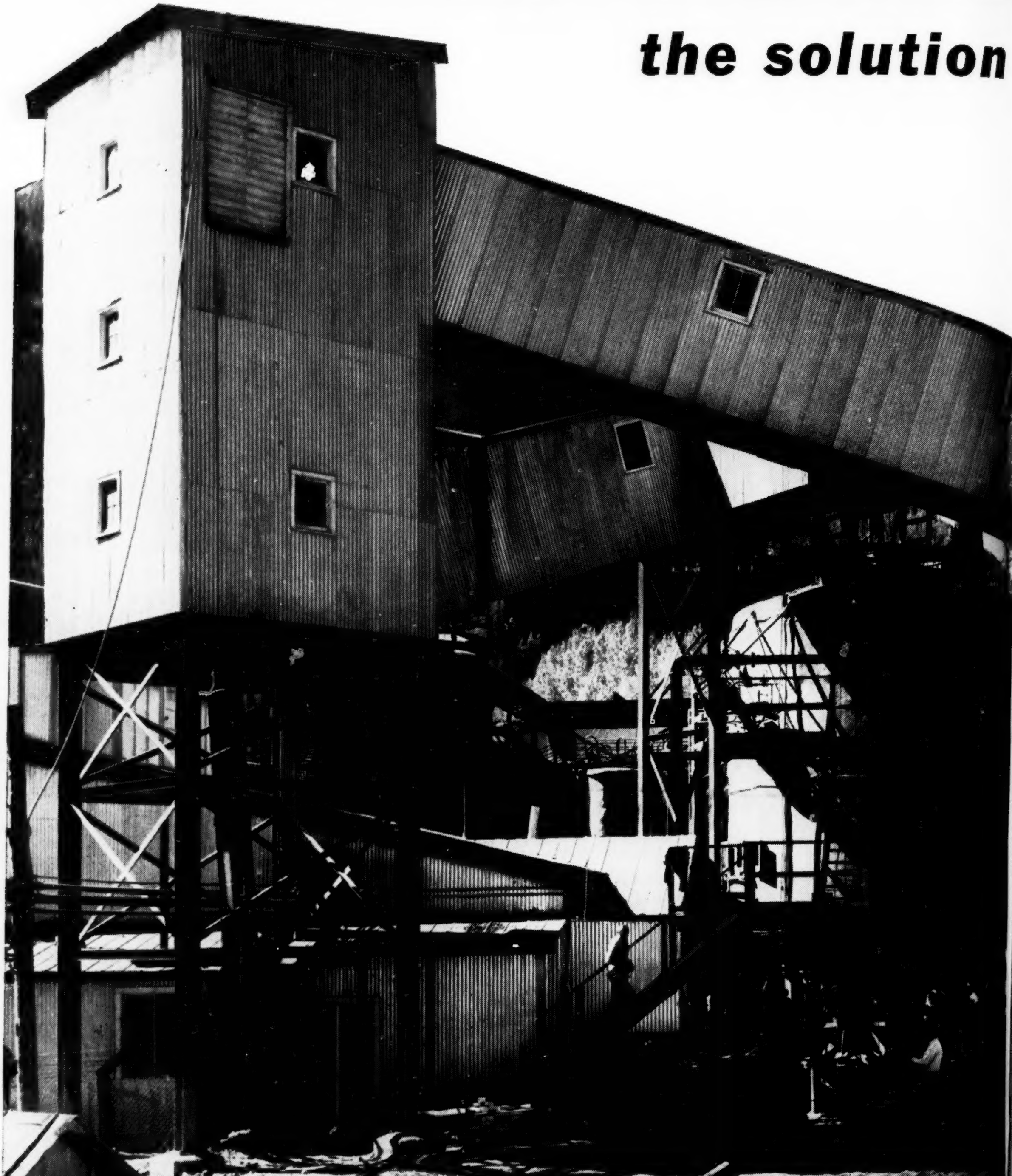
Corn Products has just ordered a Dorr FluoSolids system for reactivating 25 tons/day of spent carbon. Dorr plans to provide a two-compartment reactor, with a 6-ft., 8-in. I.D. upper chamber and a 4-ft. lower chamber. Unit will operate at temperatures in the range of 1,000 to 1,800 F.

First two dextrose plants to switch from bone char to granular carbon as decolorizing agent—CP at Pekin, Ill., and Clinton Foods, Clinton, Iowa—have been using multiple-hearth Herreshoff kilns to reactivate spent carbon (*Chem. Eng.*, Sept. 1955, pp. 122-124). Vertical tube-type kilns used for bone char

(Continued on page 144)

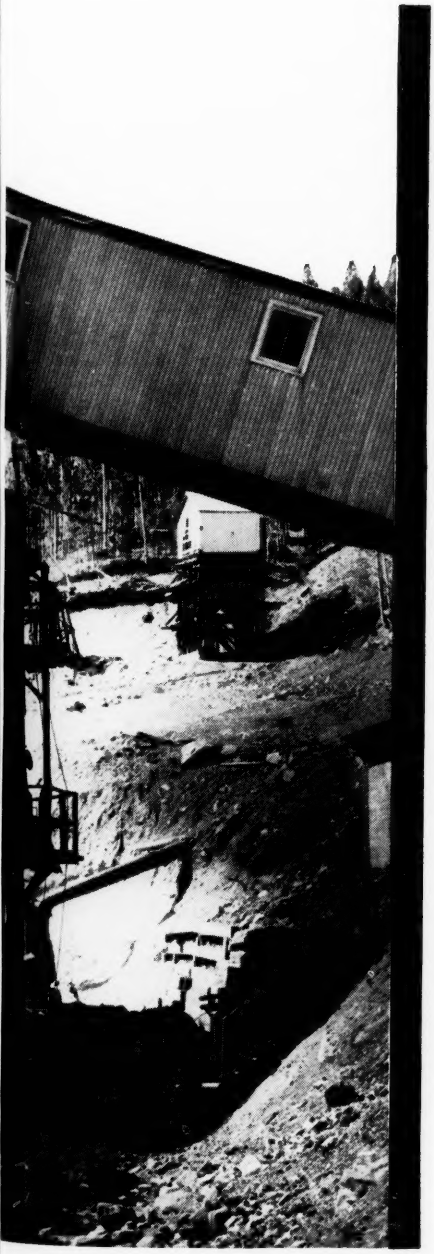
FLUOSOLIDS

the solution



SYSTEM

to SO_2 production at RICO ARGENTINE



RICO, COLORADO — Concentrating lead and zinc for many years the Rico Argentine Mining Company has accumulated a large tailings pile of sulfur bearing pyrite. Recent mine developments have revealed massive pyrite deposits. This abundant source of pyrite combined with the heavy sulfuric acid requirements of nearby uranium industry made the construction of the Company's new 200 T/D contact acid plant feasible.

An important part of this unique installation is the Dorrco FluoSolids System recently put on stream. Feed to the System is 150 to 200 tons per day. Roast is accomplished in a 20 ft. inside diameter Reactor with temperature automatically held at 1650F. Gas production is 48,500 to 63,500 CFM. Gas strength averages 14%. Unusual? Yes, because this installation is remotely located nearly 9000 ft. above sea level. Large gas volumes — normally associated with high altitude operation have had no adverse effects on operating results obtained. The high gas strength realized by use of a Dorrco FluoSolids System makes it possible to reduce gas purification equipment to an economic minimum as compared with other type roasters producing a weaker gas. Other advantages of the FluoSolids System are simplicity and ease of operation. Due to the FluoSolids Reactors high unit capacity it is possible to efficiently produce a larger volume of SO_2 gas in a single unit thereby reducing capital costs.

For detailed information about the FluoSolids System — write Dorr-Oliver Incorporated, Stamford, Conn., U. S. A.

FluoSolids is a Trade Mark of Dorr-Oliver Inc. Reg. U. S. Pat. Off.

DORRCO

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

reactivation couldn't be run hot enough to do the job.

However, Pittsburgh Coke & Chemical, maker of the granular carbon, has been banking on successful development of a more efficient, less costly revivification technique to help open bigger markets for its product. PCC has its eye, of course, on the huge potential for granular carbon in refining of sucrose.

To this end, PCC has experimented with a pilot-model fluid-bed kiln at Neville Island.

Latest PCC idea is to use a simple, direct-fired rotary kiln. Results from a small experimental unit look promising, and may be even more attractive than fluid-bed reactivation for moderate-size installations.

Lubricate your bearings with a gas film

Gas-lubricated bearings are emerging from the status of laboratory curiosities and are now beginning to find practical uses in industry.

Though not yet commercially available, this type of bearing is getting a lot of attention from engineers in the chemical, textile, nuclear, instrumentation, aircraft and machine tool fields.

In a gas-lubricated bearing, the shaft rides on a film of gas separating it from the bearing surface. In the hydrostatic type, compressed gas is supplied continuously to the bearing. But the big interest lies in the hydrodynamic type, which pressurizes its own gas film.

Absence of lubricant yields several advantages, such as:

- There is no possibility of contamination from a lubricant. This is important to textile and synthetic fiber people.
- Friction is far below that of the best liquid-lubricated or antifriction bearings. It's due only to viscous drag of the gas film.
- There is no limitation in operating temperatures, either high or low.
- In nuclear energy work, there is no problem from breakdown of lubricant because of irradiation, nor are "hot" particles of worn bearing metal produced.

Du Pont has a large number of gas-lubricated bearings operating in synthetic fiber plants at speeds of 5,000-25,000 rpm. Pratt & Whitney has developed a gas-lubricated high-speed grinder, driven by an air turbine.

Gas-lubricated bearings may play a big part in nuclear energy development. They are being tried, with good initial results, in a closed nitrogen cycle in which heat from a nuclear pile is converted to shaft energy via a gas turbine.

British engineers at Harwell are testing a self-lubricated compressor which circulates carbon dioxide at 100 psi. in a high-temperature test loop. In another test, a liquid-metals pump uses a helium-lubricated bearing. Performance of bearings up to 7 in. dia. has been investigated.

Precipitators recover wet-process acid

First electrostatic precipitators ever to be used in a wet-process phosphoric acid plant will be put into operation next month by Virginia-Carolina Chemical Corp. at Nichols, Fla.

The new units will recover concentrated phosphoric acid which escapes the acid concentrator as mist.

Each precipitator consists of 56 carbon tubes, 10 in. dia. by 12 ft. long, enclosed by a carbon and acidproof brick shell. Electrodes are silver wire.

Until now, mist has been effectively removed from concentrator offgases by a venturi scrubber. But the acid value of the mist was lost to the process.

The precipitators will recover this mist as usable concentrated phosphoric acid. V-C expects its value to pay out the precipitators' capital cost in less than a year.

Solar furnace uses artificial sunlight

If you're interested in studying the behavior of materials at high temperatures, you can now get started without having to build your own equipment.

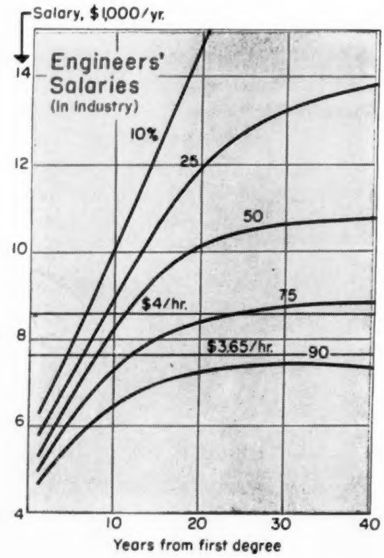
For $14,500, Arthur D. Little will supply you with a 60-in.-dia. solar furnace capable of focusing solar energy on a 6-mm. target at temperatures up to 3,500 C. This is a bargain price, for the Stellite-coated parabolic mirror itself, if you bought a new one, would cost about $20,000. ADL is using Army surplus searchlight reflectors, available at $600 each.

And for about $30,000, neither snow nor rain nor gloom of night will stay you from completion of your experiments. For ADL has developed a twin-mirror furnace which uses a source of "artificial sunlight"—described only as a high-intensity electric arc. This permits

(Continued on page 146)

round-the-clock, indoor "solar energy" research.

Another advantage of the artificial source is that you can get temperatures as high as 6,000 C. Heat flux at the target is a dazzling 7 million Btu./(hr.) (sq. ft.)



New data re: Does engineering pay?

Figures in this chart present an authoritative picture of what industry-employed engineers earned last year. They are based on a salary survey conducted by Engineers Joint Council, released last month.

Answer to the question of whether an engineering career is economically worthwhile, however, is still up to the individual making the analysis.

Rutgers University's E. B. Peck, interpreting the data in a preview for EJC's general assembly in January, compared engineers' salaries with skilled craftsmen's wages.

If this 1956 salary picture remained frozen for the next 43 years, a "median" engineer entering the profession last year would earn, during his entire career, $80,000 more than a building-trades craftsman working full time at $3.65/hr. (e.g., carpenter or electrician). The differential would be only $50,000 vs. a $4/hr. craftsman (plumber or bricklayer).

Like Paul Stewart (*Chem. Eng.*, Sept. 1956, pp. 192-4), Peck doesn't consider these differentials large enough to constitute "an attractive return" on the engineer's investment in his education.

He fails, however, to define what he considers an attractive return. Nor does he offer any basis for assuming that building-trades craftsmen work 2,080 hr./yr. throughout their entire working lifetime. He also omits the value of fringe benefits.

Real worth of EJC's survey is that it establishes a reliable benchmark for administration of engineers' salaries. It stakes its claim to credibility by virtue of its large sample (93,000—nearly one-fifth of all industry-employed engineers) and its reliable data source (payrolls of 350 companies).

New refineries converge on Northwest

Add Texas and Richfield to the growing roster of major oil refiners in the Puget Sound area of Washington.

Richfield, in January, bought about 1,000 acres of land 14 miles northwest of Everett. Refinery size and construction schedule have not yet been finalized.

Texas Co. announced on February 1 that construction would start about March 1 on a new 40,000-bbl./day refinery near Anacortes.

Only a few weeks earlier Standard of California disclosed preliminary plans for a refinery near Everett of 60,000-100,000 bbl./day capacity.

As recently as three years ago, this area was completely devoid of major refineries. General Petroleum was first on the scene, completing a 37,000-bbl. refinery at Ferndale late in 1954. Expansion projects now under way will add another 11,000 bbl. of capacity.

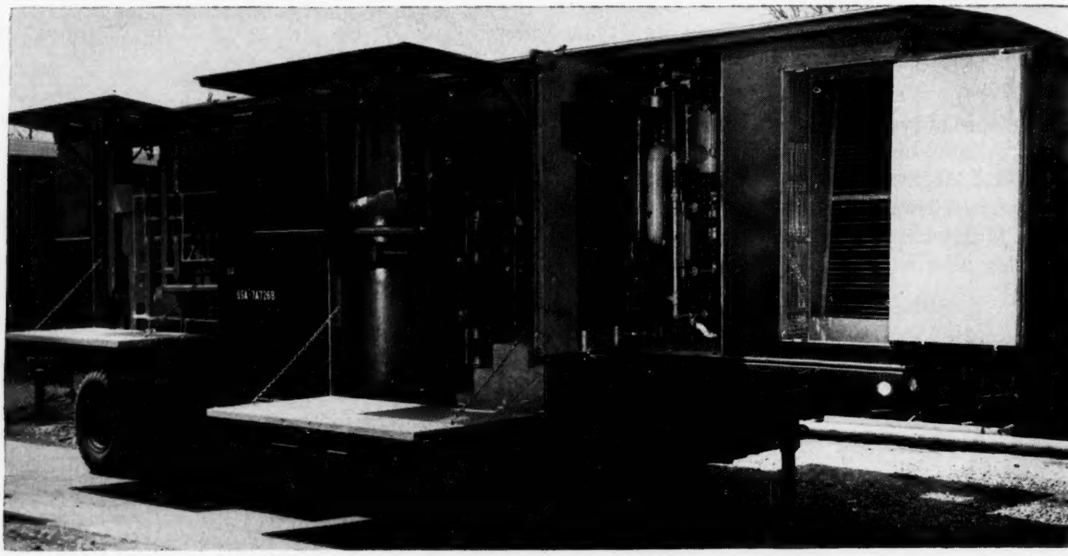
Shell was close on General's heels, with its 50,000-bbl. refinery coming on stream in mid-1955. U. S. Oil & Refining Co. has a 15,000-bbl. refinery at Tacoma nearing completion.

Of the other two western majors, Union admits more than passing interest in the area; Tidewater disclaims any serious interest.

Why the big refining boom in this particular area? First, of course, is the virtual refining vacuum which existed until recently. Richfield President Charles S. Jones cites also "the continued growth of population and industry" in the area.

Another important factor is that our Pacific Northwest is the logical outlet for crude oil produced in sparsely populated western Canada. This oil is already flowing by pipeline (Trans Mountain) to General and Shell.

For more on DEVELOPMENTS........148



REFORMING furnace is at left of center opening; built-in water cooling tower is at extreme right.

New Process for Portable Hydrogen Plant

Why portable unit can't use conventional processes:

$$\text{Diesel oil} \xrightarrow[\textit{combustion}]{\textit{partial}} H_2 \qquad \textbf{Requires } O_2 \textbf{ supply}$$

$$\left.\begin{array}{r}\text{Methane}\\ \text{Propane}\end{array}\right\} \xrightarrow[\textit{reforming}]{\textit{steam}} H_2 \qquad \textbf{Requires special hydrocarbon supply}$$

How new portable unit avoids these problems:

$$\text{Diesel oil} \xrightarrow[\textit{reforming}]{\textit{steam}} H_2 \qquad \textbf{No supply problem}$$

The hydrogen plant shown in these pictures boasts two departures from convention. One of them is readily apparent—mobility.

Second novel feature — and more important to the chemical engineer — is that this plant makes 98% hydrogen by catalytic steam-reforming of diesel oil. Up to now, steam-reforming has been limited to lighter hydrocarbons, such as methane or propane; heavier hydrocarbons have been used to make hydrogen only via partial oxidation processes.

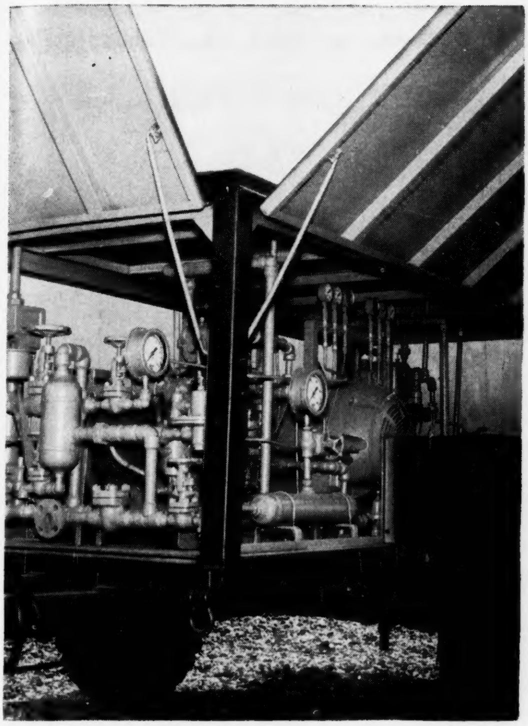
The Girdler Co., Louisville, Ky., developed the portable 1,000-scf./hr. hydrogen plant under an Army contract. It was recently delivered to the Engineer Research and Development Laboratories, Ft. Belvoir, Va.

▶ **Field Supply Problems**—During World War II Girdler supplied the armed forces with a number of portable plants which produced hydrogen via the catalytic reaction of methanol and steam. For the new one, however, the Army wanted to be independent of methanol or any other material which would involve a field supply problem. The Army wanted to be able to use diesel oil or other fuels readily available in the field.

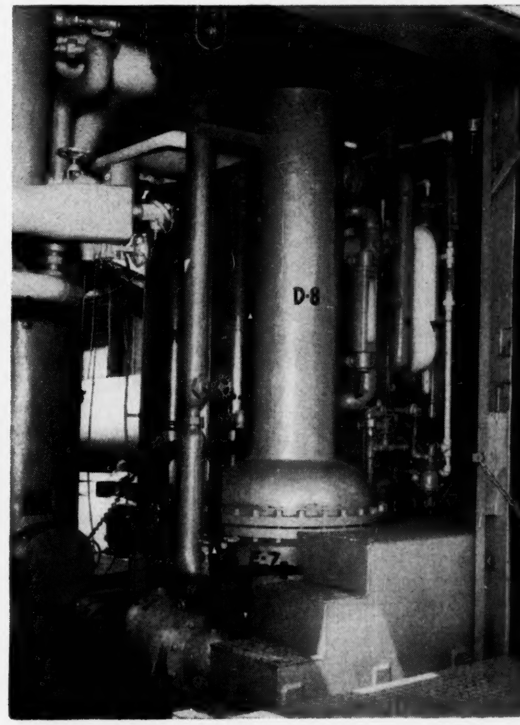
To produce hydrogen via partial combustion of oil, a route which Girdler is currently helping to bring into commercial reality for ammonia manufacture via the Texaco process, requires a source of oxygen. Hence a self-supporting plant would have to include an air-separation unit.

Girdler engineers chose the steam-reforming process, therefore, despite anticipated trouble from carbon deposition on the reforming catalyst. Extended test operation showed, however, that good catalyst life could be obtained provided a 2½-hr. steaming period follows each 21½-hr. on-stream period.

▶ **Compact Size**—Limitations on size are most noticeable in design of the reforming furnace. The usual industrial steam-hydrocarbon reformer uses vertical catalyst-filled tubes ranging



HYDROGEN compressors occupy second semitrailer.



ABSORBER and reactivator fit into low headroom.

Solves Field Supply Problem

from 20 to 40 ft. long. The ERDL model uses tubes less than 8 ft. long. There are four of them, each about 6 in. dia., made of a heat-resistant type of stainless steel.

Even the absorber and the monoethanolamine reactivator, which usually tower 30 or more ft. high in a conventional unit, have been shoe-horned into the low headroom of the mobile semi-trailer-mounted unit. To help accomplish this, Girdler engineers split the absorber into two 7-ft.-high sections, operated with gas flow in series and MEA flow in parallel.

▶ **Includes Auxiliaries**—In addition to the process equipment itself and associated control instruments, the semitrailer also houses:

• A 15-hp. steam generator to furnish entire steam requirements for reforming, shift conversion and MEA reactivation. It can produce 500 lb./hr. of 100 psig. steam.

• Boiler feed water treating and heating system.

• A water cooling tower, complete with basin and fan, designed to cool 50 gpm. of water from 110 F. to 90 F. with wet bulb of 80 F.

• Oil storage tank, holding one day's supply of diesel oil. It has an electric heater for cold-weather operation.

Only equipment not included is a pair of hydrogen compressors, mounted on a second semi-trailer for safety reasons.

▶ **Process Flow** — Diesel oil is mixed with superheated steam, and the vaporized mixture then passes through the reformer tubes, which contain a nickel catalyst. The endothermic heat of reaction is provided by burning more diesel oil in the furnace space surrounding the tubes. Steam superheat comes via a coil in the furnace stack.

Reforming reaction, which produces hydrogen, carbon monoxide and carbon dioxide, is carried out at somewhat higher temperature and steam-to-carbon ratio than normally used to reform methane or propane.

More steam is mixed with the reformed gases, and this mixture goes through a shift converter, containing iron oxide catalyst. Here the carbon monoxide in the gas is converted to carbon dioxide, with the formation of an additional equivalent amount of hydrogen.

The gas is cooled, then stripped of its CO_2 content by contacting with 20% monoethanolamine solution in the packed absorbers. The hydrogen is compressed to 2,275 psi. in a four-stage angle compressor. MEA is reactivated by stripping off the CO_2 in a packed tower equipped with a steam-heated reboiler.

Italy Will Buy Two Nuclear Reactors

Edison Volta, Italian power company, will buy a 134,000-kw. nuclear electric power plant from Westinghouse Electric Corp.

Nuclear reactor will be of the

heterogeneous, pressurized-water type, using 2.7%-enriched uranium fuel. The plant will be similar to the one to be built for Yankee Atomic Electric Co. at Rowe, Mass., which is expected to cost about $34.5 million. The plant will probably be operating by 1959 or 1960.

However, the Italian and U. S. governments must first work out an agreement for exchanging technical information and data. And Edison Volta will want to make sure it can get the enriched fuel it needs to power the reactor.

Another 5,000-kw., heavy-water, research reactor will be sold to Comitato Nazionale Richerche Nucleari of Italy.

Reactor will be a main research facility of CNRN's nuclear program, and is now being designed in Washington by nuclear energy products division of ACF industries. On-stream date: 1958.

Germanium Bites Deeper Into Electrochemical Field

Diamond Alkali Co. plans to install the nation's largest germanium power rectifier system as part of a multimillion-dollar expansion program at its Deer Park, Tex., plant. To provide direct current to a chlorine cell line, the installation will be rated at 35,000 kw., 250 d.c. volts.

The installation was designed in cooperation with General Electric. It exceeds the total capacity of 40 rectifier installations made since GE pioneered the first large germanium power rectifiers in 1953, and is GE's first U. S. sale at a voltage rating above 150.

The installation adds strength to predictions made here a year ago (*Chem. Eng.*, Feb. 1956, p. 126) that germanium would find its electrochemical niche in the medium-voltage range. Quoting Max I. Alimansky, general manager of GE's rectifier department at Lynn, Mass., "It fills a long-standing need in the electrochemical industry for conversion equipment rated between 150 and 400 v. Previously there has been no equipment that could give the same benefits to customers in the lower voltage ranges that mercury-arc rectifiers could offer in the higher voltage ranges."

Fluid Coking Unit Processes 42,000 Bbl./Day

World's largest fluid coker, recently completed at Tidewater Oil Co.'s Associated, Calif., refinery, is four times as large as nearest competitor and is being joined by an identical unit at Tidewater's Delaware refinery near Wilmington. Fluid coking produces petroleum coke and light oils from heavy oil.

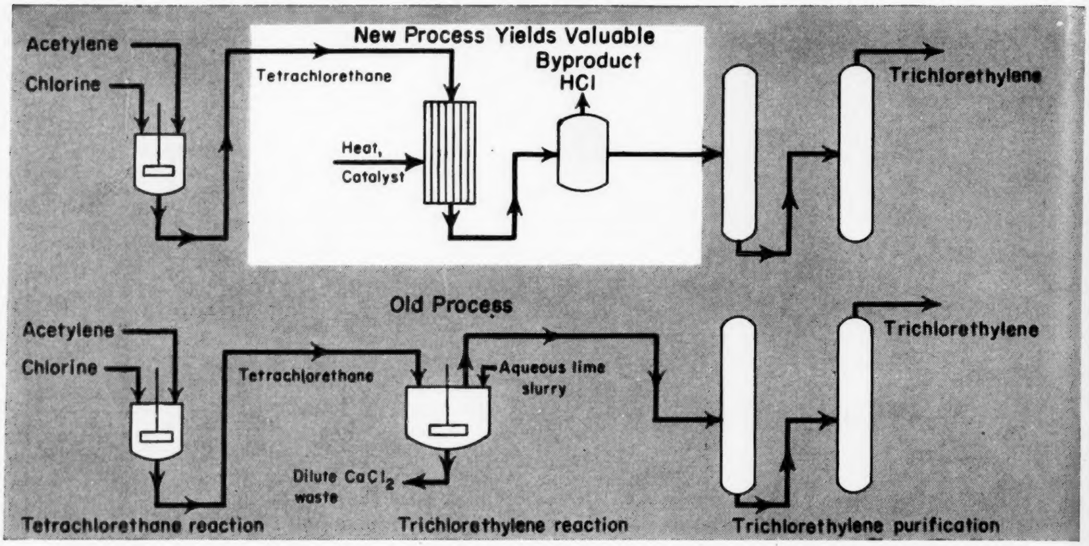
More Ethylene Oxide, Glycol for U. S., Germany

Ever-hungry plastics industry is prompting stepped-up production of ethylene oxide and ethylene glycol for booming markets in the U. S. and West Germany.

Farbenfabriken Bayer at Leverkusen, West Germany, will set up a new ethylene oxide plant to produce about 24 million lb./yr. for further processing to ether and esters. Scientific Design Co. will build the plant, which will employ direct oxidation of ethylene.

Direct oxidation process also will be the basis of General Aniline & Film Corp.'s new Linden, N. J., plant to produce 60 million lb./yr. of ethylene oxide and 35 million lb./yr. of ethylene glycol. SD Plants, Inc., subsidiary of Scientific Design, has already started construction of the $8-million plant.

Jefferson Chemical Co. is launching a major expansion at Port Neches, Tex., that will double ethylene glycol capacity, up ethylene oxide output by 50% and triple its ethylene production.



HCl Value Puts Cracking Process in Front

Trichlorethylene makers are now recovering as HCl the chlorine values that used to go down the drain as dilute calcium chloride in the old lime process.

Catalytic cracking process for making trichlorethylene gained additional support with the startup last summer of Columbia-Southern Chemical Corp.'s new unit at Barberton, Ohio.

The bulk of U. S. output of this high-tonnage solvent is now made via catalytic cracking of tetrachlorethane, as opposed to the older process in which tetrachlorethane is dehydrochlorinated by aqueous lime slurry. One industry expert estimates that cracking now accounts for about two-thirds of present trichlorethylene production.

Du Pont was first U. S. producer to adopt the cracking process commercially. The company began conversion in the late 1940's, now turns out a "major portion" of its trichlorethylene (made at Niagara Falls, N. Y., and Wyandotte, Mich.) via cracking. During 1955 Hooker-Detrex (now Detrex Chemical Industries) swung most of its production at Ashtabula, Ohio, over to the cracking route.

▶ **Recovers HCl**—In either process, tetrachlorethane (made by the addition reaction of acetylene with chlorine) becomes trichlorethylene by the loss of one mole of HCl. In the lime process, this HCl goes down the drain as low-value calcium chloride.

The cracking process, on the other hand, produces anhydrous hydrogen chloride as a valuable byproduct. Detrex pipes its HCl gas directly across the fence to General Tire, who reacts it with acetylene to make vinyl chloride. Columbia-Southern and Du Pont use their byproduct HCl in several other internal operations; C-S also sells some to the trade as muriatic acid.

Building a new trichlorethylene plant and converting an old one to cracking involve two different sets of economic conditions. Cracking is more than competitive with the lime process for anyone planning a new plant, according to a Detrex engineer, even without a paying outlet for HCl. But to justify replacement of existing lime-process facilities, you need the extra credit for HCl. The other former Hooker-Detrex plant, at Tacoma, Wash. (now operated by Hooker Electrochemical), still uses lime.

▶ **Newest Plant** — Columbia-Southern engineers are proud of several features of their new trichlorethylene plant:

- The acetylene chlorinator is designed for a high ratio of throughput to catalyst. The improved chlorinator, worked out after considerable study by C-S research and development people, reduces the size of chlorinator needed, lowering investment and maintenance costs and enhancing ease of automatic control.
- C-S engineers designed the heat exchange equipment so that contacts of water or steam with chlorinated organics are unlikely. This avoids moisture contamination, which not only can cause off-quality products but can be disastrous in maintenance.
- Infrared plant-stream analyzers continuously maintain high chemical purity standards of the product.

▶ **Vapor Degreasing** — Trichlorethylene's amazing growth in the past 20 years is due largely to its widespread adoption by the metal trades as a vapor-degreasing sol-

"Built for his grandson to walk on!"

BETTER WOOD PRESERVATIVES MADE WITH RCI PENTA

● Penta-protected wood lasts up to 4 times as long as untreated lumber. This kind of protection is a profitable investment for people with maintenance problems ... whether they're running a park department or a light and power company.

Water-repellent solutions made with RCI PENTA protect lumber against decay and termite attack... keep wood dimensionally stable ... reduce its tendency to crack or check. Wood protected by RCI PENTA solutions is clean, easy to handle.

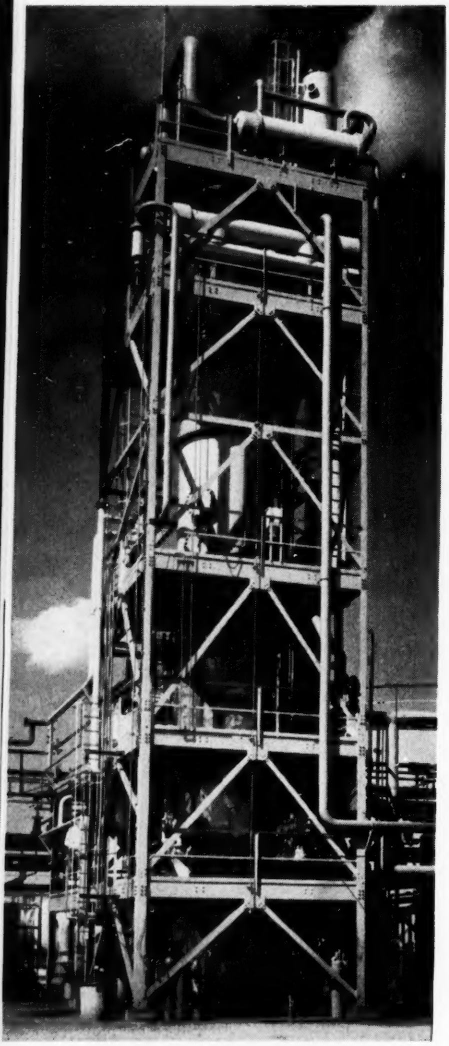
Today, penta treatment is the fastest growing method of preserving wood. And RCI, one of America's fastest growing chemical companies, is a top source for pentachlorophenol. If you're currently engaged in, or are considering, the manufacture of wood preservative solutions, fungicides, bactericides, algicides, or herbicides... or if you do your own treating of lumber, call Reichhold for pentachlorophenol ... now being produced by RCI's Pacific Northwest Division in Seattle.

REICHHOLD

Synthetic Resins • Chemical Colors • Industrial Adhesives • Plasticizers
Phenol • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride
Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sulfuric Acid

REICHHOLD CHEMICALS, INC.,
RCI BUILDING, WHITE PLAINS, N. Y.

Creative Chemistry . . . Your Partner in Progress RCI



CRACKING produces trichlorethylene in C-S's new reactor.

vent. About 90% of today's output is so used.

American manufacturers first entered the trichlorethylene market in 1925 to provide the young vapor-degreasing industry with a relatively safe solvent having a high flash point.

By today's standards, initial growth rate was small; in 1934, total manufacturing capacity was only 15 million lb. Then expansion began in earnest, with a huge push in the early 1940's from war demands. Industry capacity today is well over 400 million lb./yr.

Postwar demand has lagged behind capacity. Production last year was about 320 million lb., and anticipated output this year is about 340 million lb.

▶ **Market Developments** — Improved grades of trichlorethylene, while benefiting the customer, may have contributed to a slowing down of growth rate.

For example, Du Pont in 1954 introduced a new degreasing grade which features a nonsludging stabilizer system. According to Clark Shepherd, of Du Pont's chlorine products division, this new grade lowers solvent consumption 10% by extending the useful life of the solvent inventory in the machine.

Columbia-Southern's Charles E. Grant, manager of solvent sales, also claims a stabilizer system "new to the industry and designed for the most exacting customer." And Detrex claims that its "exclusive" process step of purifying tetrachlorethane before cracking it to trichlorethylene gives a premium grade.

Looking into the future, Du Pont's Shepherd is optimistic about a new development which could give trichlorethylene demand a welcome shot in the arm. This is a dip painting process in which trichlorethylene is the solvent base. The coated piece is dry in just a few minutes after removal from the paint bath, and there is said to be no loss of solvent or paint. The process is already being used by one large automobile manufacturer in three plants.

Oxygen: U. S. Expands, Britain Compresses

While three U. S. firms busily expand oxygen-producing facilities, British Oxygen Company, Ltd., is just as busily spending $5.6 million to compress oxygen in six plants throughout Britain.

Air Reduction Co. is building a $6.5-million bulk oxygen plant in Chicago, Ill., to be on stream in about a year. Plant will serve nearby steel mills and is situated to take advantage of rail and water facilities.

Elbowing for a competitive edge, National Cylinder Gas Co., plans new or bigger oxygen facilities at Chicago, Ill., San Leandro, Calif., San Juan, Puerto Rico and Maracay, Venezuela. National Cylinder's Huntsville, Ala., hydrogen-compressing plant recently started up to meet demand for electrolytic hydrogen to process metals.

In plants abuilding or soon to be built, Linde Air Products Co. will boost the nation's oxygen-producing capacity by 2 billion cu. ft./mo. Most new capacity will go to steel industry to step up production and boost quality of steel.

During the next two years, British Oxygen will also build a dissolved-acetylene works, loading docks, a garage to accommodate 60 trucks and, tentatively, a unit which will produce nitrous oxide.

Canada Will Get New Natural Gas Pipelines

New 174-mi., 30-in. natural gas pipeline from southern Alberta to the U. S. and British Columbia is part of a $100-million pipeline expansion program by Westcoast Transmission Co.

Westcoast President Frank M. McMahon said that $55 million will be spent to add compressor stations and other facilities to boost capacity of the $170-million Peace River pipeline (now under construction) from the currently planned 400 million cu. ft./day to 660 million cu. ft./day.

Remaining $45 million will be used to construct a 500-ton/day sulfur plant in Alberta and to build the new 30-in. pipeline, which will originate in the Savanna Creek area of Alberta and serve areas in British Columbia.

Pipeline expansion is neccessary because, in addition to 350 million cu. ft./day contracted by Pacific Northwest Pipeline Corp., B. C. Electric Co. and Inland Natural Gas Co. have hiked demands by exercising options to take substantially larger volumes.

Gas for the new line will be supplied by Phillips Petroleum Co. under a contract guaranteeing 150 million cu. ft./day from the Savanna Creek field, owned by Phillips.

For surface finish formulation . . .

SHELL AROMATIC SOLVENTS

with wide variety of evaporation ranges

These Shell solvents cover a very wide evaporation range. Their individual characteristics satisfy specific requirements in a great variety of formulations. Detailed specifications are given in a booklet which will be sent upon request.

Write for your copy.

SHELL TOLUENE
. . . for applications where very fast evaporation and high solvency are required.

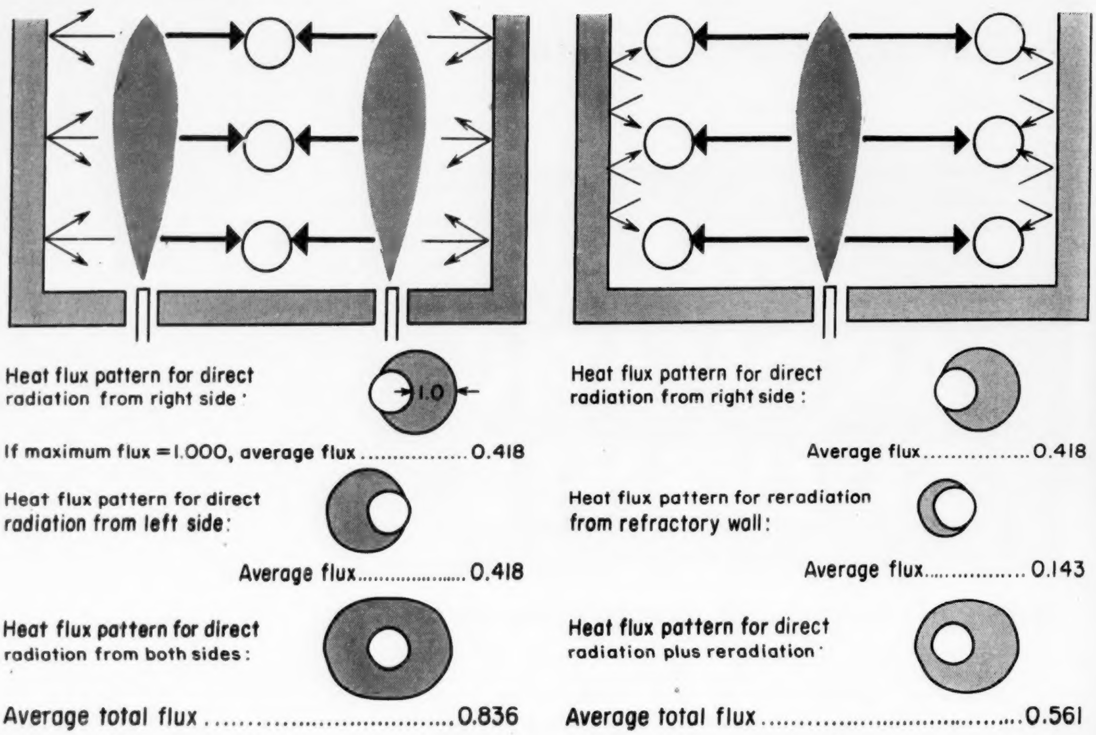
SHELL XYLENE
. . . has an exceptionally narrow distillation range, is slower drying than toluene.

SHELL CYCLO-SOL 53
. . . an excellent solvent with higher flash point and slower evaporation than xylene.

SHELL TS-28 SOLVENT
. . . a still slower drying aromatic concentrate of medium high solvency.

SHELL OIL COMPANY

50 WEST 50TH STREET, NEW YORK 20, NEW YORK
100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA



Double-Fired Heater Needs Less Tube Area

Direct radiation from two sides instead of only one boosts average heat flux by 50%, saves also on maintenance cost and pressure drop.

New process heater design—based on double-firing of vertically suspended tube banks—has chalked up impressive efficiency records during its first tryouts by Sun Oil Co. and is now generating added interest among other design engineers.

Sun built its first four heaters of the new design for use with a Houdriformer unit at Marcus Hook, Pa., and, except for two routine shutdowns for equipment inspection, these heaters have been operating continuously since November 1953. Three larger heaters of similar design went on stream at Marcus Hook in August 1955.

So happy is Sun with the seven heaters now operating that the company is thinking of buying ten or twelve more of the same design for a wide range of uses.

► **Why Double-Firing?**—Sun developed the new heater design in cooperation with Alcorn Combustion Co., Philadelphia. Alcorn is now finding itself with other interested customers.

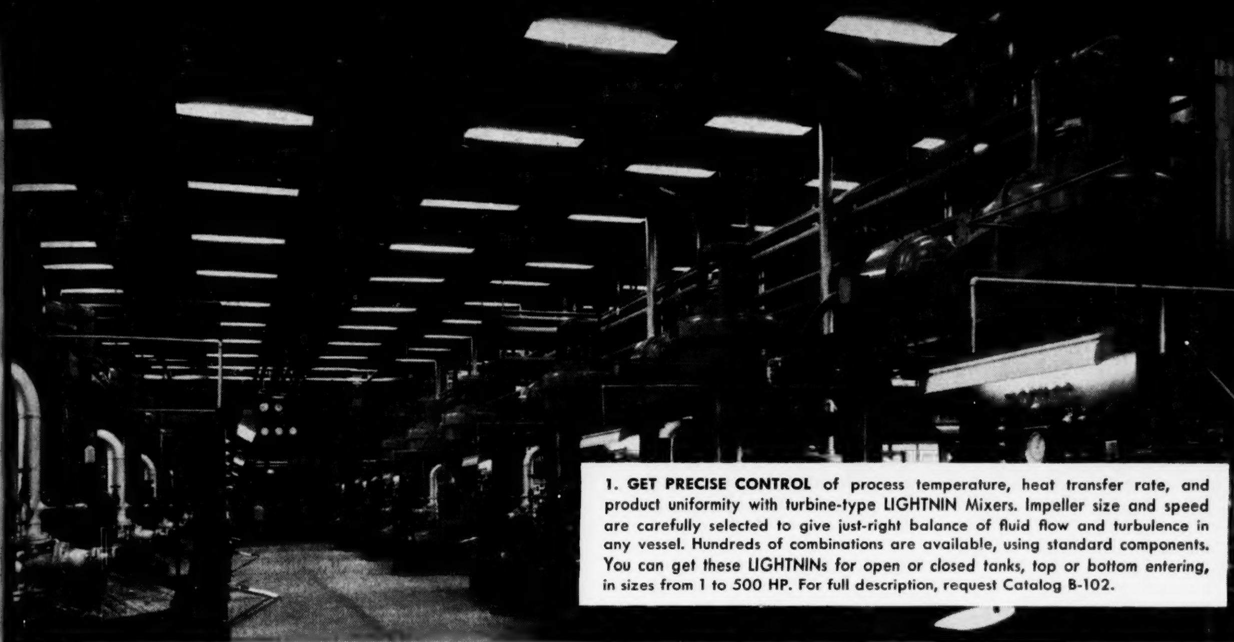
Double-firing principle uses direct transmission of radiant heat to tube banks from two sides, rather than radiating from only one side and reradiating from the other, as in conventional heater design.

Boosted efficiency is only one of double-firing's benefits, says Ralph Morrow, design engineer with Sun's manufacturing department. Experience at Marcus Hook shows that easier maintenance and less down time are definite pluses also resulting from the new design.

► **Effectiveness Up 50%**—Construction of the heaters involves multiple-pass tube banks sandwiched between "radiation planes" of horizontally mounted burners. The burners, located at several elevations, fire in vertical planes parallel to and on both sides of the tube bank. Conventional heater design relies on reradiation from a refractory surface.

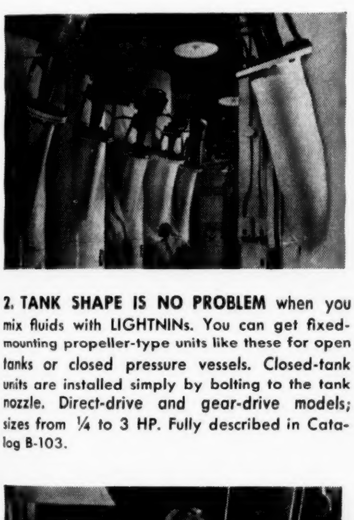
Direct result of double-firing is increased effectiveness of tube surface. The chart above compares conventional wall-tube banks with double-firing tube banks. Double-firing boosts tube effectiveness by almost 50%.

► **Better Heat Transfer**—One way of stating the practical result of this is that with the same fuel consumption, two tubes fired on both sides will absorb the same amount of radiation as will three tubes fired only on one side. This cuts



1. GET PRECISE CONTROL of process temperature, heat transfer rate, and product uniformity with turbine-type LIGHTNIN Mixers. Impeller size and speed are carefully selected to give just-right balance of fluid flow and turbulence in any vessel. Hundreds of combinations are available, using standard components. You can get these LIGHTNINs for open or closed tanks, top or bottom entering, in sizes from 1 to 500 HP. For full description, request Catalog B-102.

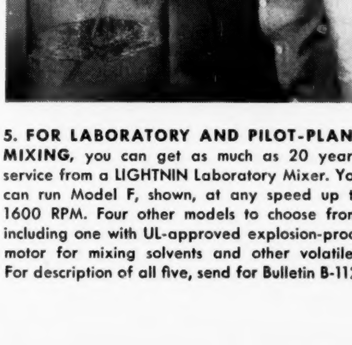
5 ways to get the right **fluid mixing** *for your process*



2. TANK SHAPE IS NO PROBLEM when you mix fluids with LIGHTNINs. You can get fixed-mounting propeller-type units like these for open tanks or closed pressure vessels. Closed-tank units are installed simply by bolting to the tank nozzle. Direct-drive and gear-drive models; sizes from 1/4 to 3 HP. Fully described in Catalog B-103.

3. FOR VERY LARGE TANKS (up to 6 million gallons), you can get high volumetric flow at low cost with a LIGHTNIN Side Entering Mixer. It fits new or old tanks; comes with choice of stuffing box or rotary mechanical seal that's quickly replaceable if it ever wears out. Gear-drive and V-belt drive models; sizes 1 to 25 HP. Described in Catalog B-104.

4. GET RAPID DOUBLE-MIXING ACTION, or gentle thorough stirring, in any open vessel, with a LIGHTNIN Portable Mixer. Direct-drive models for high-speed mixing of thin liquids; gear-drive units for heavier fluids or larger batches. You can get LIGHTNIN Portables, electric or air driven, in sizes from 1/8 to 3 HP. Thirty models. For full description, request Catalog B-108.



5. FOR LABORATORY AND PILOT-PLANT MIXING, you can get as much as 20 years' service from a LIGHTNIN Laboratory Mixer. You can run Model F, shown, at any speed up to 1600 RPM. Four other models to choose from, including one with UL-approved explosion-proof motor for mixing solvents and other volatiles. For description of all five, send for Bulletin B-112.

How to take advantage of what's new in mixing

There are many ways you can use modern fluid mixing to help product quality; increase yield; get better uniformity; speed production.

It takes a specialist to give you full advantage of today's highly developed mixing skills. Your LIGHTNIN Mixer representative can give you this kind of help, because he's backed by *35 years of specialization* in fluid mixing.

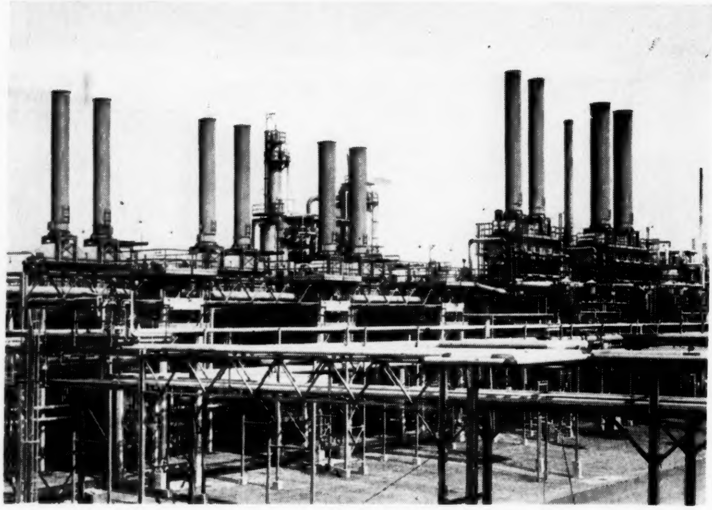
For quick, competent assistance on any fluid mixing problem, call him today—or write us direct.

Lightnin Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT CO., Inc.
128-C Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd.
100 Miranda Ave., Toronto 10, Ont.



HEATERS of new design serve Sun's two Houdriformers at Marcus Hook.

tube length and tube surface requirements by one-third.

Tube life, too, benefits from double-firing. Less total tube length means greater mass velocity of the fluid inside for a given pressure drop. The improved film coefficient that results allows the same heat transfer at lower tube-wall temperatures.

Also, length of tube travel is critical in high-pressure processes where design engineers must be stingy with pressure drop.

► **Marcus Hook Setup**—A typical heater at Marcus Hook is designed to heat 18,000 bbl./day of Houdriformer charge and resembles basically a huge cube 37½-ft. high, with a center slice —the convection section—rising to 52½ ft. Combustion gases leave through two stacks.

Charge is heated entirely in the radiant section, the convection section being used to generate 450-psig. steam.

The radiant section consists of two rows of four parallel tube banks branching from two main headers, with a total of 112 tubes.

Heat (176.7 million Btu./hr.) is supplied via 80 National Airoil oil-and-gas burners. Charge enters the two headers at about 800 F., flows through the eight tube banks and leaves the heater at about 950 F.

► **Design Advantages**—The vertical tube banks, rising to a height of about 35 ft. inside the heater, are suspended from the top and merely guided at the bottom. For this reason, they remain straight at high temperatures. Series-parallel coil arrangements are easy to make.

Burners may be fired with either oil or gas, and using preheated air makes no difference in the over-all efficiency of the heater.

Sun's next move will be to use these versatile double-fired heaters in other processing units, such as visbreakers and pretreaters. Other petroleum refiners and chemical processors will likely swing over to double-firing after evaluating the new design.

U. K. Develops New Route To Make Mg Refractories

Britain is developing a new process for making better magnesia refractories for use in steelworks and iron foundries.

Process involves lower temperatures than those normally used in manufacturing dense magnesium oxide refractory materials and depends on the application of special additives to the raw materials before firing. Since additives are converted into volatile gases when heated, they are automatically eliminated during the firing process and leave pure magnesium oxide refractory as the finished product.

Temperatures for firing the refractory are on the order of 2,350 F. in this process, as compared with 3,000 F. required in conventional magnesia refractory manufacture.

Firms to Make Tall Oil Chemicals, Styrene Foam

In two steps designed to bolster their positions in materials and markets, Monsanto Chemical Co. joined Emery Industries to make tall oil chemicals and teamed with St. Regis Paper Co. to develop production and market possibilities for foamed-styrene-and-paper "sandwich" material.

Under the agreement with Emery, a jointly owned plant will be built at Monsanto's Nitro, W. Va., location for fractionating crude tall oil into unsaturated fatty acids and tall oil rosin. Plant is scheduled to be on stream in spring of 1958; cost: $4 million. St. Regis Paper Co. will supply crude tall oil from sulfate pulp mills under a long-term agreement. Plans call for barging tall oil to the Nitro plant from St. Regis mills in Florida.

New foamed-styrene-and-paper "sandwich," known as Fome-core Board, is a core of stiff foamed styrene sandwiched between two sheets of specification kraft paper. Board is produced in continuous operation, retains high compression strength under severe humidity conditions and has good insulation qualities. St. Regis will begin limited commercial production of a new container made from this board.

New Process Makes Organic Microfibers

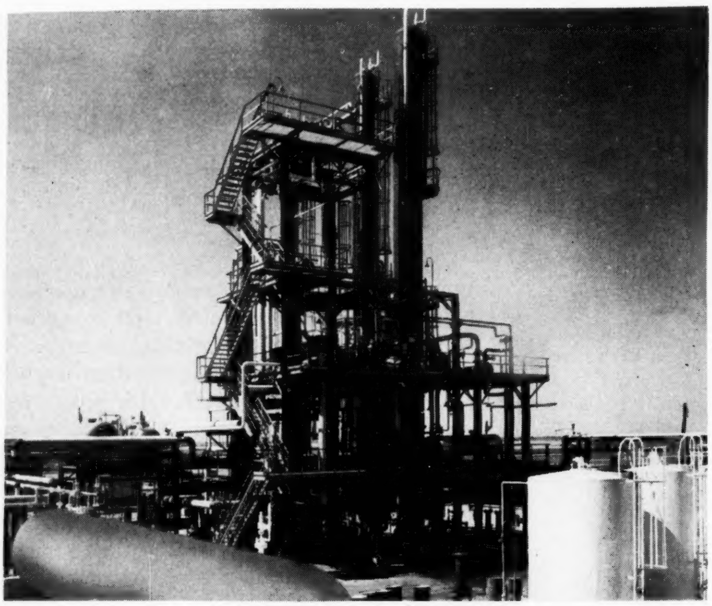
Now available for licensing from American Viscose Corp. is a patented process to make superfine organic fibers.

In the new process, polymers such as vinyl, acrylic, nylon and polyester resins, as well as amor-

phous materials, are dissolved in volatile solvents and sprayed into an air stream to form fibers having a permanent electric charge, irregular length and diameters from 0.5 to 10 microns.

Microfiber webs are highly absorbent, and the static charge makes them highly efficient filters for oils, dust and smoke.

Process has been in pilot operation for a year at Avisco's Marcus Hook, Pa., plant.



New CCl_4 Plant Boasts Unique Features

Chlorination unit has flexible operation; low-temperature fractionation prepares feed.

Modern design and latest process developments mark Frontier Chemical Co's. new chlorohydrocarbons plant at Wichita, Kan.

Designed by C. F. Braun and incorporating unconventional reaction and feed-purification steps, the 20-million-lb./yr. plant is now on stream to meet booming demands for methylene chloride, chloroform and especially carbon tetrachloride.

▶ **Aims at Fumigant Sales**—Idea for the chlorination plant gelled when Frontier began searching out markets for its increasing chlorine production at Wichita (now approaching 200 tons/day).

Market research turned up the fact that wheat required a sizable chunk of the 20 million lb./yr. of carbon tetrachloride used in compounding grain fumigants—and Kansas is the largest wheat-producing state.

With a ready-made market and raw-material supplies near at hand—including methane from nearby Kansas natural gas wells, Frontier began deliveries from its new plant in December.

▶ **New Process Twists**—Although Frontier now aims for carbon tetrachloride sales, President Curtis Cannon asserts that the chlorination unit is flexible enough to produce nearly 100% yields of methylene chloride or chloroform. At present, the company has no plans for methyl chloride.

Frontier's engineers won't talk details about the reaction step. But they do say reactor equipment is different from any used before for this purpose, and that reaction takes place at moderately elevated temperatures.

Feed-preparation step employs fractionation at super-low temperatures, rather than the more common oil absorption method. Fractionation step removes C_2, C_3 and higher hydrocarbons which may produce solid substances on reaction with chlorine. Low-temperature front end of the Wichita plant was designed by L'Air Liquide.

Product stream from the reactor contains two to four different chloromethanes. These are separated into product and recycle streams by intensive fractionation (one tower is 118 ft. high), since customers' specs call for 99.9% purity of all products.

Recycle streams are sent through reactor again to suppress by mass action the formation of unwanted products.

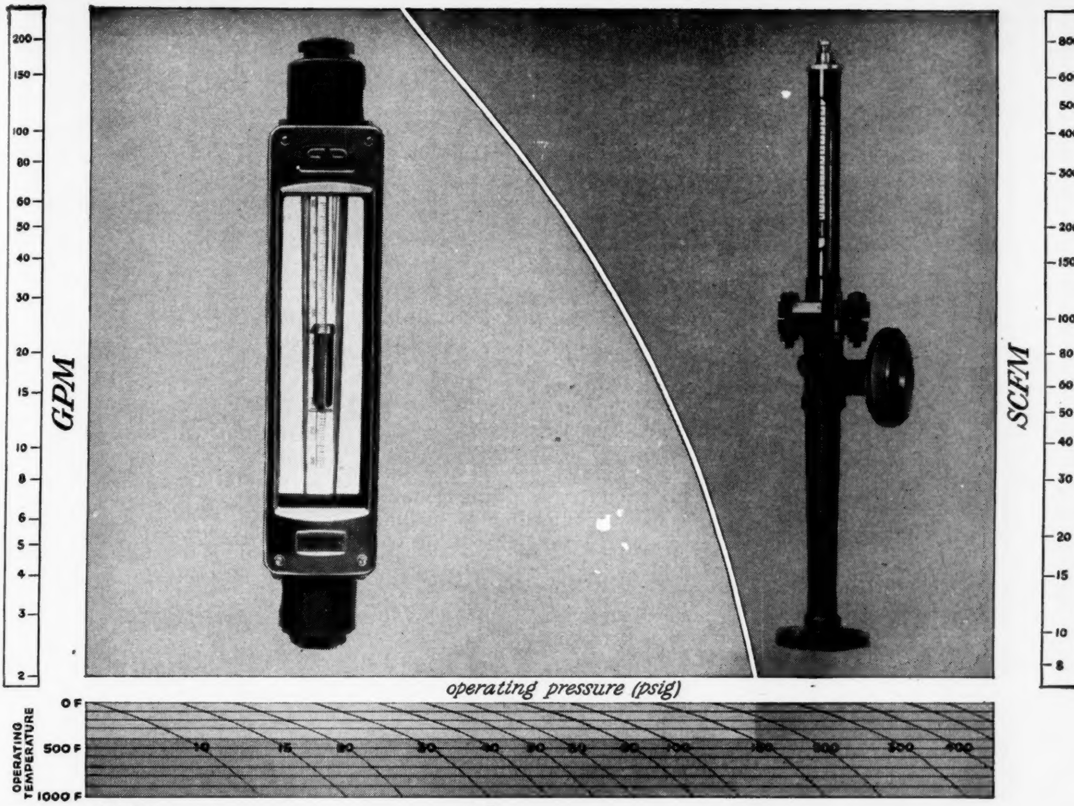
Titanium Powder Gets New Production Boost

United International Research, Inc., Long Island City, N. Y., is planning to up capacity of its electrolytic-process titanium powder plant to meet increased demand for this product.

This increase is the first one since UIR completed its commercial-size plant in the spring of 1955. Original commercial unit (consisting of three cells) was built at a cost of about $250,000 and produced 15,000 lb./mo. of stable powder.

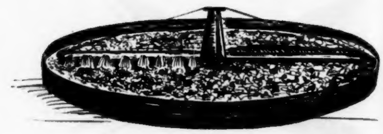
Process (*Chem. Eng.*, Aug. 1954, p. 104) starts by electrolyzing titanium dioxide and continuously leaching to minimize hydrogen contamination. Powder stability is thought to be attained by formation of a layer of oxide or nitride on the particles.

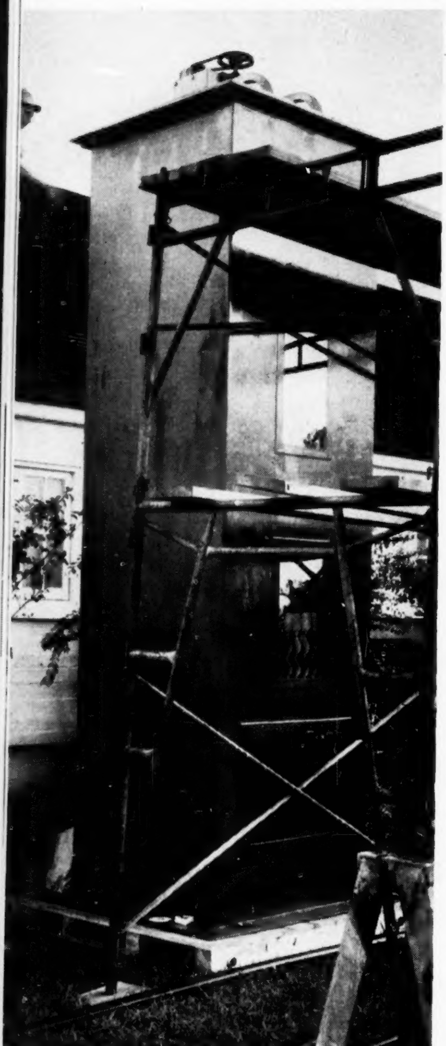
Titanium powder is in demand for such powder-metallurgy products as gears, bearings, grinding wheels, chemical reagents and paint pigments.


GPM
200
150
100
80
60
50
40
30
20
15
10
8
6
5
4
3
2
SCFM
800
600
500
400
300
200
150
100
80
60
50
40
30
20
15
10
8
operating pressure (psig)
OPERATING TEMPERATURE
0 F
500 F
1000 F

SMALLER EQUIPMENT, FASTER PROCESSES . . .

What's New in Bio-Oxidation





POLYSTYRENE-packed tower is Dow's bid for bio-oxidation jobs.

"Trickling filters for industry are on their way out."

So says a noted authority on bio-oxidation techniques for disposal of organic wastes.

Conventional filters — those big, circular beds of crushed stone fed from rotating sprinkler arms—are yielding to modified versions with different packing media, to aerated lagoons, to constantly improving methods and equipment for activated sludge treatment.

For example, the pulp and paper industry is now almost exclusively on activated sludge, and oil refineries are in the process of swinging over. In the past five years activated sludge treatment of industrial wastes has gained many new devotees.

Although slowly losing favor in practice, the conventional trickler retains great usefulness in principle. Simple modifications and adaptations may prove expedient, such as Sun Oil's use at its Toledo refinery of ordinary cooling towers as units for bio-oxidation of process wastes (*Chem. Eng.*, July 1956, pp. 128-130. And Fluor Products Co. has considered offering a trickling filter designed somewhat like a cooling tower.

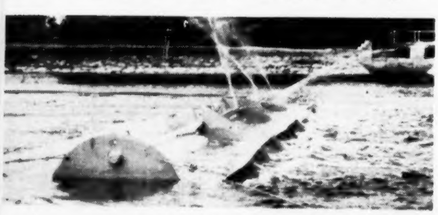
▶New Shapes, New Media—Work now under way hits directly at conventional tricklers' most glaring drawbacks—high construction costs, large land needs, limited effectiveness of BOD removal unless multiple units used, and gradual overall deterioration as partial clogging causes channeling and efficiency decline.

Dow Chemical, searching for volume outlets for polystyrene, has been working on a so-called "oxidation tower"—a trickling filter built as a tower and using a corrugated plastic medium, Dowpac, in place of familiar crushed stone.

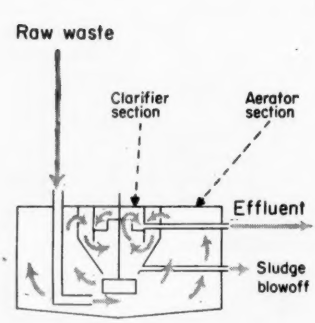
Dow is rumored to have ten or more pilot oxidation towers around the country (its Midland unit is 42 ft. high) working on effluents from food plants, paper mills, oil refineries and chemical works. At least one Dowpac tower has attained commercial status, at Great Northern Oil's Minnesota refinery, installed by Fluor.

Entry of a big chemical company like Dow, with its technical and promotional skills, should produce results in a field long dominated by sanitary engineers.*

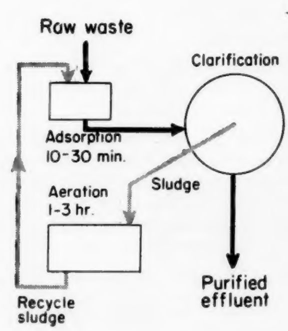
* Dow, reticent about making commercial claims for Dowpac right now, regards its program as strictly developmental because it can't service inquiries until more facts are available.



FLOATING aerator turns over lagoon contents 1-2 times daily.



INSIDE-OUT sludge aerator-clarifier copes with high-BOD wastes.

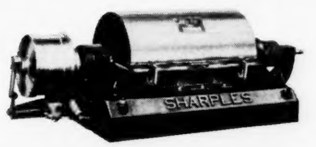


SEGREGATION of aeration and adsorption speeds waste along.

SHARPLES · Headquarters for PARTICLE CLASSIFICATION

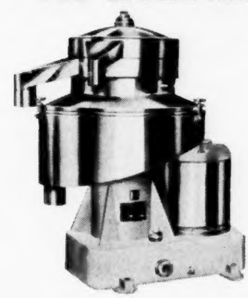
WET PROCESSING

The SHARPLES SUPER-D-CANTER



Continuously handles particles in slurries from a few microns in size up to 1/4" diameter, with solids contents ranging from 1% up to thick sludges—clays, ores, plastics, chemicals.

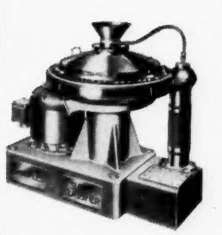
The SHARPLES DH-3 NOZLJECTOR



The heavy-duty, continuous concentrator-classifier with high efficiency on even the tough jobs. Built-in recycle feature. Rugged drive delivers full 50 HP to the bowl. The DH-3 classifies extremely fine particles at high capacity.

DRY POWDERS

The SHARPLES SUPER CLASSIFIER



A revolutionary innovation in dry powder classification in the particle size range of approx. 10 to 125 microns—the Super Classifier combines sharpness of separation with high capacity and high product recovery.

The SHARPLES Micromerograph

PARTICLE SIZE DISTRIBUTION ANALYSIS

Particle size distribution analysis can be made of fine dry particles in 15 minutes to 2 hours with accuracy within 3%. The Sharples Micromerograph is fast becoming the standard instrument of industry.

Take advantage of Sharples' leadership in particle classification —send us your problems for evaluation and recommendation.

Fluor's proposed trickling filter medium is redwood packing. Redwood media should give greater freedom to air and water flow than crushed rock, would be relatively impervious to organic solvents.

▶ **"Inside-Out"** — Activated sludge's competitive advantages in industrial waste treatment have been honed of late by newer equipment and high-rate systems of processing. Clever example of former is Infilco's Aero-Accelator, a device for accomplishing waste-sludge contact, aeration and sedimentation continuously in the same equipment.

Newest variation is the IO ("inside-out") unit. This device reverses positions of clarification and aeration units in the older AR Aero-Accelator, so that aeration chamber is on outside and sedimentation zone on inside. This makes sense for high-BOD wastes (dividing line is about 600 ppm. BOD) when the oxidation requirement increases more rapidly than does the clarification requirement.

The AR Aero-Accelator had limited usefulness for strong wastes, since the clarification zone, being on the periphery, had to be oversize to accommodate an adequate aeration zone on the inside.

First IO-type unit will be on stream this spring at General Petroleum Corp.'s Ferndale, Wash., refinery. Another is being installed for treatment of deinking wastes for Kalamazoo Paper at Kalamazoo, Mich. Other IOs are being considered for thiosulfate and furfural disposal.

Infilco's 50-ft. IO Aero-Accelator at Ferndale supplements two 27-ft.-dia. AR units, is sized to remove essentially all phenolics from waste flow containing an ultimate 675 ppm. BOD. Internal clarifier, rated at approximately 0.5 gpm./sq. ft., is 35 ft. in diameter.

▶ **Delayed Oxidation**—A high-rate activated sludge process just breaking into the commercial spotlight is contact stabilization. Now in pilot-plant tests at Glatselter Paper Co., Spring Grove, Pa., contact stabilization defers oxidation of BOD adsorbed on activated sludge until after sedimentation and removal of purified effluent.

Through-time for waste material is only the 10-15 min. spent adsorbing BOD, not the 1 to 3 hr. required to oxidize or stabilize BOD-contaminated sludge for subsequent treatment with more raw waste. And tankage is reduced, for in contact stabilization you need aerate a smaller volume of material (effluent removed).

▶ **Float, Don't Settle**—Sedimentation in activated sludge processes can be a slow affair and costly in terms of equipment. Flotation of floc particles in waste liquor via a 40-60-psi. pressure release can give nearly complete separation of sludge from effluent in 20-40 min. Flotation yields a more concentrated sludge for return to waste liquor and can handle floc which otherwise would settle poorly. Merck is using flotation in its activated sludge plant in Danville, Pa.

One of the simplest of all waste disposal techniques resembles neither a trickling filter nor an activated sludge route; it's the aerated lagoon. Any lagoon will aerate itself naturally in, say, two weeks' time. This may provide a convenient, low-cost means to continuously oxidize liquid wastes; if you've got plenty of land but you're short on capital, just bulldoze a shallow hole in the ground and you've got a naturally aerated lagoon.

If you can't spare the space required for natural aeration, you'll want to speed up the aeration with mechanical agitation. But this is easier said than done economically for a sizable body of water. Consulting engineer Thomas Riddick has equipment which may fill the bill. Riddick's device, a floating aerator, is at present turning an 80-million-gal. reservoir (serving Ossining, N. Y.) over completely one to two times daily. Power input: only 8 hp.

Riddick's aerator delivers 160 cfm. 8 ft. below the surface, breaking thermal stratification, equalizing temperature, oxygen content, pH, iron content, etc.

Hilton Davis Chemical is impressed enough by the Ossining reservoir performance to be seriously considering a floating aerator for lagoons at its dye and pigment plant in Cincinnati.

Convention Calendar

American Society of Heating and Air-Conditioning Engineers, 13th International Heating & Air-Conditioning Exposition, International Amphitheatre, Chicago, Feb. 21-Mar. 1.

American Institute of Chemical Engineers, national meeting, Greenbrier Hotel, White Sulphur Springs, Va., Mar. 3-6.

National Assn. of Corrosion Engineers, 13th annual conference and exhibition, Kiel Auditorium, St. Louis, Mo., Mar. 11-15.

1957 Nuclear Congress; consists of second nuclear engineering and science congress, 5th atomic energy in industry conference. Convention Hall, Philadelphia, Mar. 11-15.

Chemical Market Research Assn., Sheraton Hotel, Philadelphia, Mar. 12-13.

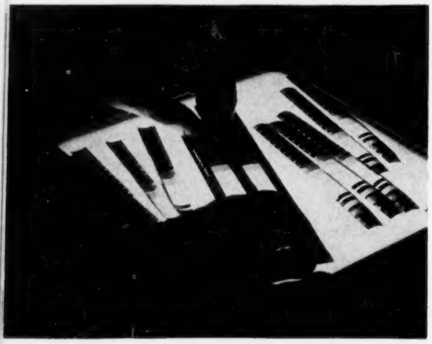
Gas Turbine Power Conference, Sheraton-Cadillac Hotel, Detroit, Mich., Mar. 18-21.

Society of the Plastics Industry, annual national conference and Pacific Coast plastics exposition, Hotel Biltmore, Los Angeles, Mar. 18-21.

American Society for Metals; 10th western metal congress and exposition, Pan-Pacific Auditorium (titanium conference, Ambassador Hotel), Los Angeles, Mar. 25-29.

United States World Trade Fair, international exposition, New York Coliseum, New York, Apr. 14-27.

American Society for Testing Materials, in conjunction with American Institute of Chemical Engineers, American Nuclear Society and Society for Nondestructive Testing, symposium on testing applications in the nuclear field, Morrison Hotel, Chicago, Apr. 16-18.



COMPARISON of test film strips with standards helps keep tricky, complicated color film process in line. These strips come off the finishing line every 15 min.

CLOSE CONTROL IS KEY TO

Successful Color Processing

DYNACOLOR Corp., Brockport, N. Y., last year nearly tripled its 1955 total sales, which had scaled the $½-million mark. And it looks as if rate of growth in '57 will be just as good.

The firm is now set up to develop over 15,000 rolls/day of 35-mm. color film and about 12,000 rolls/day of color movie film. To handle this volume, Dynacolor now has five processing lines and plans to have two more ready for the summer rush. Seasonal peaks, such as the one last Christmas (when in a single week 200,000 rolls were heaped up on Dynacolor's doorstep) have made expansion a must.

Staff expansions, too, point up recent growth: In 1955 the firm had 20 or so employees; last year that figure spiraled to around 200; this year it may double.

►**Boom or Bust** — Eighteen months ago the Government's consent decree turned thumbs down on what it termed a monopoly by Eastman Kodak in the processing of color film. At the time, many onlookers expected a pack of hungry young contenders to devour some of the Rochester firm's lion's share of the market.

Today, though, Kodak can count its sizable competition on one hand—with Dynacolor ranking among the first to succeed.

Some of the reasons why this is so probably won't be known until many would-be processors begin talking about the snags they've run into while trying to get operations under way.*

►**Experience Essential** — Dynacolor points to its experienced personnel as the main factor behind its smooth-running venture. The reason: Process information as it appears in the now-available Kodak manual is actually only the beginning.

Despite its telephone-directory size, the manual tells you only how to get going. But it doesn't, and probably can't, tell you how to pinpoint the trouble when something goes wrong. Ability to do this, of course, is vital to any chemical process. But Dynacolor people say it's especially important in color film processing; when something acts up the "symptoms are dangerously misleading."

And knowing how to handle this type of film is Dynacolor's biggest asset. For seven years before the decree, its staff had been processing films, of its own making, which were technically similar to Kodachrome.

Besides a nucleus of trained people, Dynacolor also had sufficient starting equipment—which needed only minor adjustments to handle the Eastman film. The other alternative — getting the machinery from Kodak — would have been an economic hurdle. It's expensive to buy, and installation is both tricky and costly (total bill is over $130,000 per line).

►**Critical Elements**—Success or failure of the process hinges on close control of four critical elements: chemical compositions, timing, agitation, and temperature.

Dynacolor uses some 20 inorganic chemicals and seven organics to make up the various developers in mixing tanks. After careful analysis, the mixtures are pumped to one of the four processing rooms. Fresh mixes replenish the process solutions periodically.

Two types of washes hold off contamination from incoming film. In one, water is forced under pressure through a special spray nozzle to clean the emulsion side of the film. The other is a bath which employs air agitation and has a continuous turnover of fresh water.

Film, spliced to form an endless strip and threaded over scores of spools, is mechanically transported through the tanks of the processing machine at a constant speed of 30 ft./min. for 35-mm. and 57 ft./min. for 16-mm.

Agitation and decontamination of process solutions are taken care of in one step. Solutions are circulated by positive displacement pumps through filters and returned to the tanks through "turbulators" (perforated pipes) at the bottom of the tanks. Amount of agitation is determined by the volume of liquid, the size of the perforations and the pressure at which the liquid passes through the holes. Piping is arranged so that no stagnant pockets exist during circulation.

►**Temperature Control** — Most interesting aspect of Dynacolor's operation is the tight hold on process temperature.

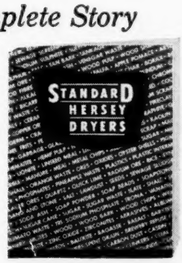
Processing is done at 80 F. but must be controlled within ±0.50 F. for most solutions and a narrow ±0.25 F. for developers. This delicate job is handled by a set of solenoid temperature regulators built by Dynacolor engineers. These highly sensitive units operate in grid circuits of vacuum tubes. They work

*Patents certainly weren't holding anyone up. Some 200 or so original patents on the process expired three or four years ago. Only those on equipment refinements are still in force.

An extra tough problem solved* with STANDARD STEEL'S usual skill!

Get the Complete Story

Write your name on the margin of this advertisement, tear out and mail with your letterhead—in a few days you'll receive the complete Standard-Hersey dryer bulletin. No obligation!



It's more than Standard Steel's routine of good design, quality materials and skilled workmanship that sells *Standard-Hersey* dryers—often it's the unusual engineering ability to *solve a difficult problem.* Time and time again new and old customers alike come to Standard Steel.

For more than 50 years, Standard Steel has developed dryers for many segments of American industry . . . . handling difficult drying jobs with trouble-free, efficient and economical service.

No matter the drying job . . . . nor how difficult the processing problem may be, *LOOK TO STANDARD!*

Remember! Standard's pilot dryers play an important part in solving your drying problems before blueprint stage.

STANDARD STEEL CORPORATION

through motorized valves to operate the refrigerating and heating units.

▶ **Corrosion Sidestep** — Vulnerable materials of construction are avoided because of the high corrosiveness of the solutions. Most equipment is made of Type 316 stainless steel. Bleach tanks, though, and piping are of bronze. The spools which thread the film are nylon, and certain other small components are composed of hard rubber.

Little maintenance work is involved with these materials; tanks are cleaned once a week, racks, once daily.

▶ **Safety**—Dermatitis is the only real problem here. And, unfortunately, constant exposure usually aggravates the situation; it seldom causes immunization. Most people are highly allergic to such developer constituents as ethylene diamine and isopropylamine. Careful cleansing, hand creams and rubber gloves are a must.

Toxic air is avoided by good ventilation, and there is no explosion hazard.

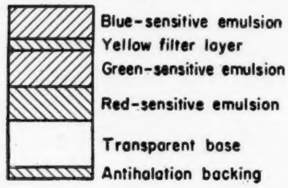
▶ **Black-and-White Film**—For a good grasp of what goes on in color processing, let's look at the makeup and development of ordinary black-and-white film.

Most films are coated with a thin emulsion of light-sensitive silver bromide in a gelatine containing organic sulfur compounds. When light falls on the film during exposure, bromide atoms become ionized, forming aggregates of silver sulfide molecules and silver atoms. These aggregates comprise a "latent image."

The image is developed in an alkaline solution of a weak reducing agent, such as hydroquinone. The solution continues the ionizing action and, finally, results in a negative image inscribed in pure silver.

▶ **Color Film**—For efficient continuous processing, individual color films are first spliced together. Then a prehardener (formalin and sodium compounds) makes the film tough enough to withstand processing.

Next step follows the routine described above for black-and-white film. Only difference is in the method of recording; blue, green and red objects register on three separate emulsions* instead of one (*see cut above*).



Steps in Color Film Processing

Preharden, wash.

Remove antihalation backing by buffing, wash.

Develop silver negative images in all three layers, wash.

Expose to red light through base.

Develop positive cyan (blue-green) color in red-sensitive layer, wash.

Expose to blue light through emulsion side.

Develop positive yellow color in blue-sensitive layer, wash.

Expose to white light through base.

Develop positive magenta color in green-sensitive layer, wash.

Bleach silver images in all three layers, bleach yellow filter layer.

Remove bleached silver images and yellow filter layer, wash, dry.

Selection of these colors is traced to the fact that controlled amounts of light of red, green and blue will yield any shade in the spectrum; in equal amounts they yield white.

After black-and-white development, the next step removes all metallic silver. But it doesn't touch the silver bromide (i.e., the color sensitivity) remaining in those sections of the layers where no latent image was formed.

Red light is then selectively passed through the film to act on all unexposed portions of the red layer. Next to act is a cyan (blue-green) color developer composed of developing agent and cyan dye coupler.†

The agent reduces the re-exposed silver halide to silver and deposits a positive black-and-white image. The agent becomes oxidized and reacts with the dye coupler, depositing an insoluble dye where the developing action occurred.

▶ **Subtractive Colors** — When projected on a screen, cyan—the complement of red — subtracts red from the white light source to produce the red in the original scene. Thus the process is a subtractive color-reversal method.

Similarly, the blue layer is re-exposed to blue light and developed in a yellow color developer; the green layer is re-exposed to white light and developed in a magenta developer.

Throughout the process, washings alternate with dye applications to prevent contamination.

A ferricyanide bleach step then converts all silver images to silver halide for easy removal in the fixing bath. The yellow filter is also prepared for removal.

After the fixing bath, the film is again washed, dried and lacquered.

Like other film processors, Dynacolor sells the silver it salvages in the fixing bath and recovers most processing chemicals and bleach. Most difficult recovery challenge is in trying to salvage the yellow developer. So far the most promising method piloted involves ion exchange.

* Since all layers are potentially sensitive to blue light, a yellow filter is placed beneath the blue layer to prevent blue rays from going farther.

† Developers contain such chemical constituents as sodium and potassium compounds, hexylene and ethylene glycol, Elon and hydroquinone.

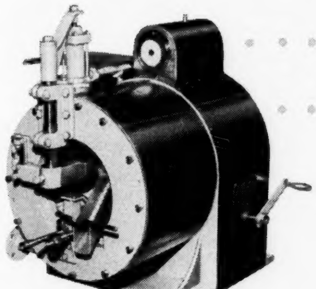
Chemical Firms Go Down on the Farm

Almost simultaneously, American Cyanamid Co. and Union Carbide and Carbon Corp. recently announced plans to concentrate pesticide and other agricultural-chemical development on their own farms.

Cyanamid will build an agricultural center and experimental farm near Princeton, N. J. Products to be tested and developed: feed supplements, veterinary products, packaged insecticides.

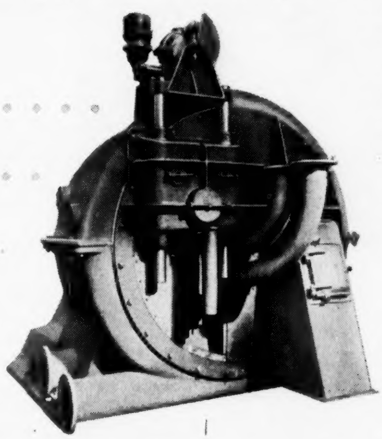
Carbide's 142-acre farm, near Raleigh, N. C., will be used for developing synthetic pesticides. Carbide figures this procedure will cut two years from the present seven-year commercial chemical development time.

From TEST RUNS in your Plant... under Your OWN Operating Conditions... To Satisfactory Operation on the Production Line...



16" Centrifugal Test Machine

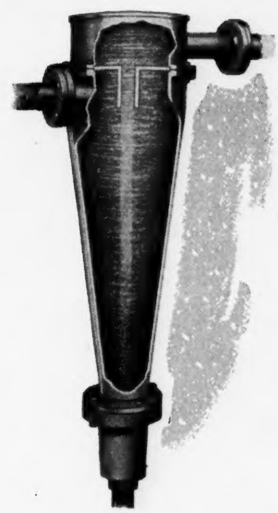
When Solids-liquid processing is your problem, we can install our 16" Reineveld for testing in your plant (with solid or perforated bowl). After a day or so of instructions, your own personnel takes over to put this pilot plant Centrifugal through its paces. Complete solids-dewatering and washing can be accomplished by this 16" Centrifugal.



79" Reineveld Centrifuge

When you have completed the tests and have established the operating cycle of the Centrifugal process, our sales engineer will then prove to you the economical values to be gained by the installation of a scaled-up production model such as the 79" Reineveld Centrifugal illustrated here.

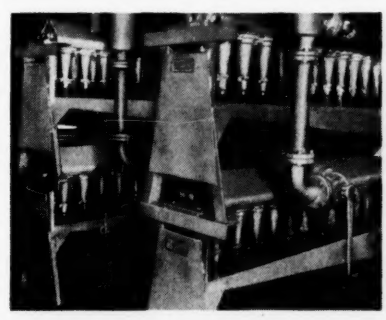
Write us for further information and request brochure RC-356, or better yet, call for a visit of our Sales Engineer.



When classifying or thickening is desired, the Heyl & Patterson Cyclone is the most economical tool for a plant where continuous flow is preferable.

H & P CYCLONES are standard in stainless steel or with rubber-lined aluminum or carbon steel bodies. They are capable of handling as little as 8 GPM, with no upper limits.

Circuits employing staged Cyclones are often used.

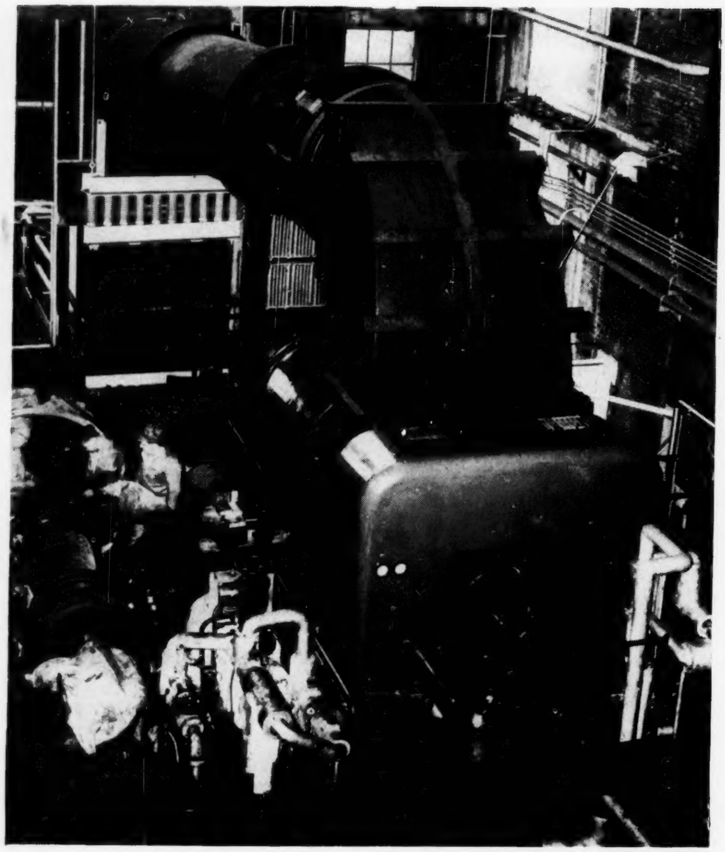


Heyl & Patterson

INC.

55 FORT PITT BLVD. • PITTSBURGH 22, PA.
PHONE COurt 1-0750

Heyl & Patterson's Cyclone Brochure C-954 available upon request.



Turbine Recovers Last Btu.

Shifts in energy demands gave Allied a surplus of 6-psig. steam at its Hopewell plant. Here's how Allied put this steam to work on a paying basis.

That giant turbogenerator pictured above is the latest and perhaps most prized addition to the powerhouse of Allied Chemical & Dye Nitrogen Div.'s Hopewell, Va., installation.

Swung on stream late in 1955, it produces up to 5,000 kw. of once-bought, sorely needed electricity from 150,000 lb./hr. of once-wasted low-pressure (21 psia., zero superheat) steam, exhausting at 3 in. Hg abs. Westinghouse Electric Corp., teamed with Nitrogen engineers, designed and built the unit.

While harnessing low-pressure steam for electricity isn't in itself unusual practice, the sheer magnitude of this particular job proved a challenge without precedent. For the unit must handle an inlet steam feed of about 3,000,000 cu. ft./hr.—the largest volumetric turbine feed now in industrial operation.

▶ **Shifting Energy Balance** — What prompted Nitrogen to tackle this pioneering assignment?

- Process steam needs at Hopewell decreased. Largely because of sharpened efficiency in the use of process heat, huge quantities of low-pressure steam from turbine exhausts, once bled usefully for processing, went to waste.
- Electrical power needs increased. Largely because of the demands of added process facilities, the plant's powerhouse, while dumping steam, had to turn to a neighboring utility for extra electricity.

▶ **Showing the Way?** — Nitrogen's response to these conditions may set a pattern for other plants similarly afflicted. The big turbogenerator now produces all the extra electricity needed.

Says Westinghouse's R. H. Stevens, "The hefty feed volumes required, more often than not, have inhibited engineers from associating low-pressure steam with substantial power production. But that turbine down at Hopewell should do a lot to change their way of thinking."

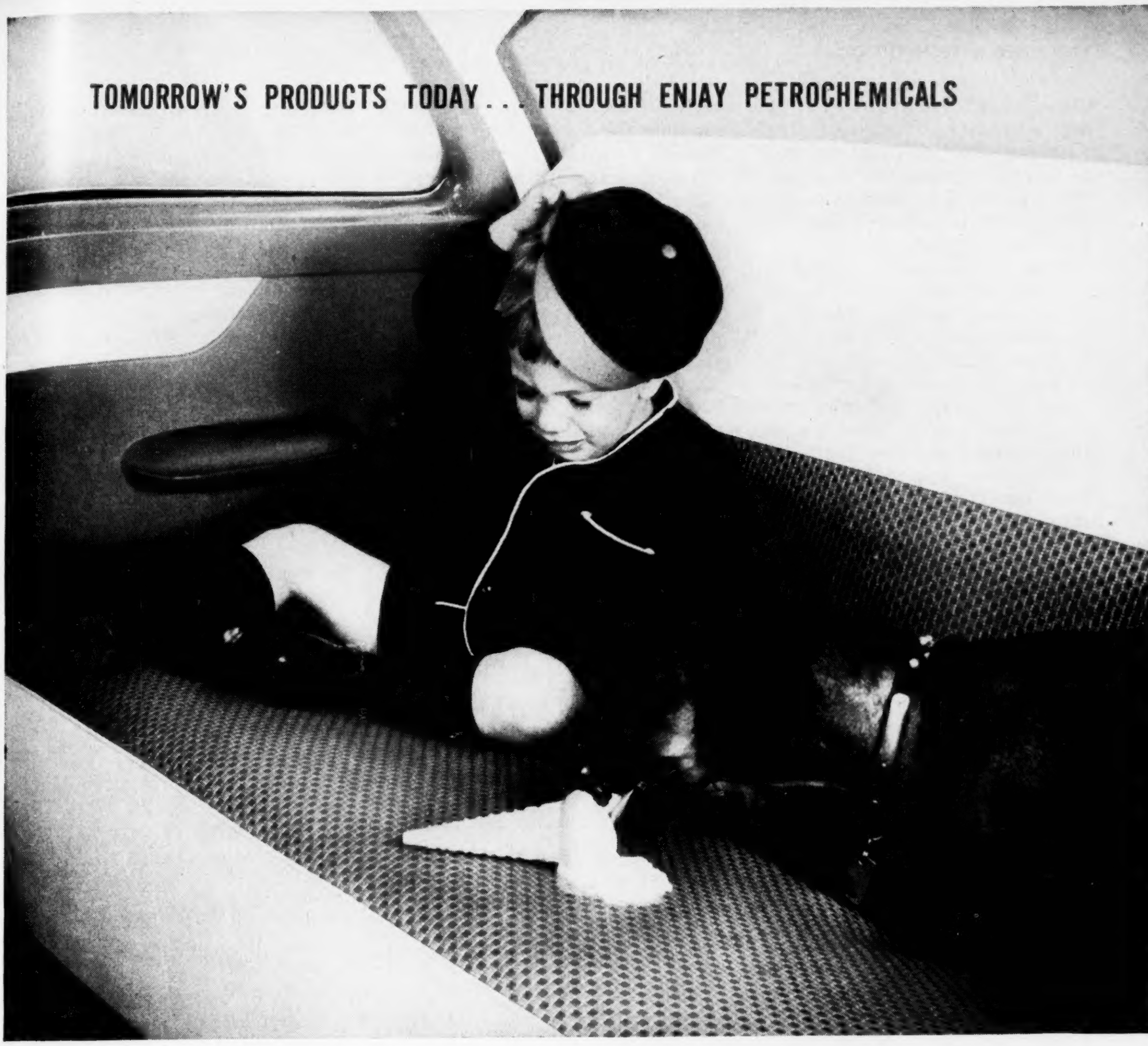
▶ **Nearly Free Electricity**—Economics of the turbine seem to back Stevens' view. Bought and installed for about $400,000, the turbogenerator unit, a Nitrogen spokesman reports, was expected to pay for itself in less than two years.

Nitrogen figures that cost of the unit's electricity stems essentially only from the initial investment. Existing powerhouse crews took over operation of the new turbogenerator routinely with their other duties. Raw material feed — the low-pressure steam—comes, of course, entirely free. And maintenance, as with most turbogenerators, is minor.

▶ **Find the Space**—Natural and economic solution that it was, the turbine nevertheless posed some tricky engineering problems. Chief among them stemmed from its space requirements.

Turbine's inlet pipe measures 30 in. dia., the exhaust line to the condenser measures 6 ft. dia. (*see photo*). The turbine itself requires about 175 sq. ft. of floor space and stands 11 ft. high, while the entire assembly requires about 300 sq. ft. The two-pass condenser, providing 10,000 sq. ft. of cooling surface, is 27½ ft. by 8½ ft. by 25 ft. high.

Economically unable to justify a separate structure for the big unit, Westinghouse squeezed it into the already well-packed



Basic raw materials for VINYLS that wipe clean as new in seconds!

One of the most popular features of the new cars is their easy-to-clean vinyl upholstery. More and more, manufacturers of the plasticizers used in hundreds of new vinyl products are depending upon Enjay Isooctyl and Decyl Alcohols to assure superior results in formulation.

If you need technical help in the application or use of any Enjay petrochemical, you can get experienced guidance from Enjay. The modern, well-equipped Enjay Laboratories have recently been expanded and are at your service. Call or write for more information.

Enjay offers a widely diversified line of petrochemicals for industry:

ALCOHOLS & SOLVENTS: Lower Alcohols, Oxo Alcohols, Ketones and Solvents; OIL & FUEL IMPROVERS: Detergent-Inhibitors, V-I Improvers, Oxidation Inhibitors; CHEMICAL RAW MATERIALS: Olefins, Diolefins, Aromatics; ENJAY BUTYL RUBBER & VISTANEX.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 W. 51st STREET, NEW YORK 19, N. Y. Akron, Boston, Chicago, Los Angeles, New Orleans, Tulsa

powerhouse. One of the existing high - pressure, noncondensing 4,000-kw. turbogenerators had to be removed and the new unit fitted to the old foundation. So, it took over the power job of the high-pressure unit as well.

Even so, the condenser had to go outdoors, some 50 ft. away. This meant carrying the man-size exhaust line that distance. To allow the long pipe to take the surging forces set up by exhaust steam expanding into the vacuum, Westinghouse fitted it with three hinge-type expansion joints which offer pipe sections sufficient flexibility to roll with the blows.

▶ **Varying Feed**—Large size of the inlet turned Westinghouse engineers away from conventional inlet valves.

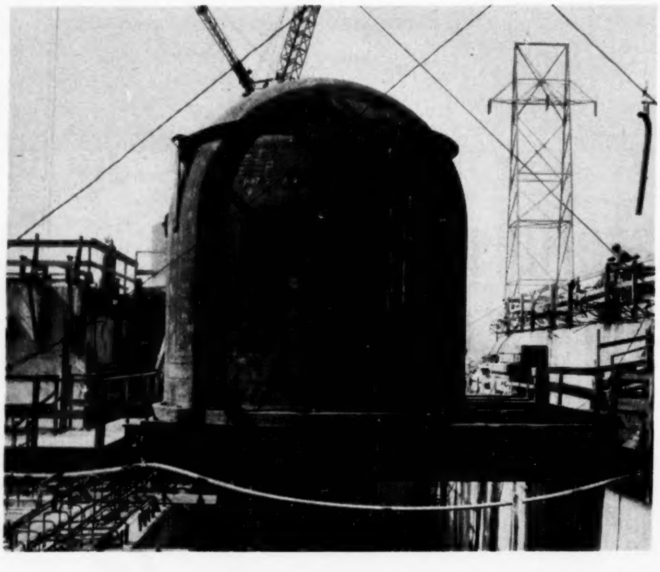
Naming, instead, the largest grid valve possible, they secured close inlet control and reduced maintenance problems. For the grid valve—a disk fitted with various-size openings that fix the inlet size much like an adjustable pencil sharpener—eliminates the traditional wear of valve seats and provides a fine variation in inlet openings.

And good inlet valve control in this installation is a real asset. With the quantity of low-pressure steam being tapped for processing purposes varying from day to day, feed to the turbine varies correspondingly. Thus, in order to maintain a constant inlet pressure, the valve opening must be continually adjusted.

A governor system does the job automatically and successfully, holding the inlet pressure firmly between 21.25 psia. and 21.75 psia. Unlike most turbogenerators, then, electrical output of this unit is determined by the inlet, rather than the exhaust, pressure.

▶ **Corrosion and Erosion**—A key problem faced in producing electricity from low-pressure steam is the threat of corrosion and erosion that springs from the high moisture content of the feed. And as the steam expands across the turbine this threat is heightened.

Most vulnerable to attack are the turbine blades. To protect them, especially at the low-pressure end of the unit, Westinghouse incorporated cobalt-based alloy (Stellite) shields and mounted moisture-removal troughs on the blades.



Top of Nuclear Reactor Container Weighs 150 Tons

Massive steel top of Shippingport, Pa., nuclear reactor container, above, is being lifted to admit reactor pressure vessel. Top is 50 ft. in diameter; entire container is 147 ft. long. Pressurized-water reactor will go critical this year.

News Briefs

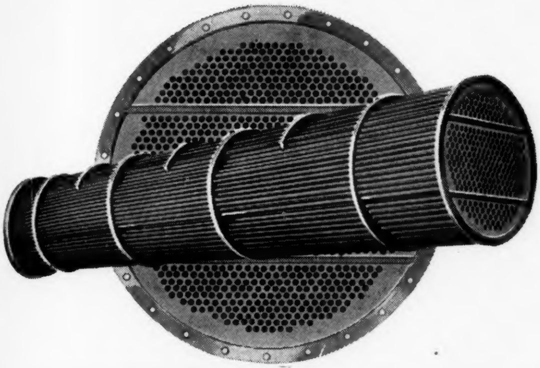
Ammonia: Asahi Chemical Industry Co. has plans for a 50-ton/day ammonia plant at Noboeka, Miyazaki-ken on Kyushu Island. Plant will use Texaco oil-gasification process.

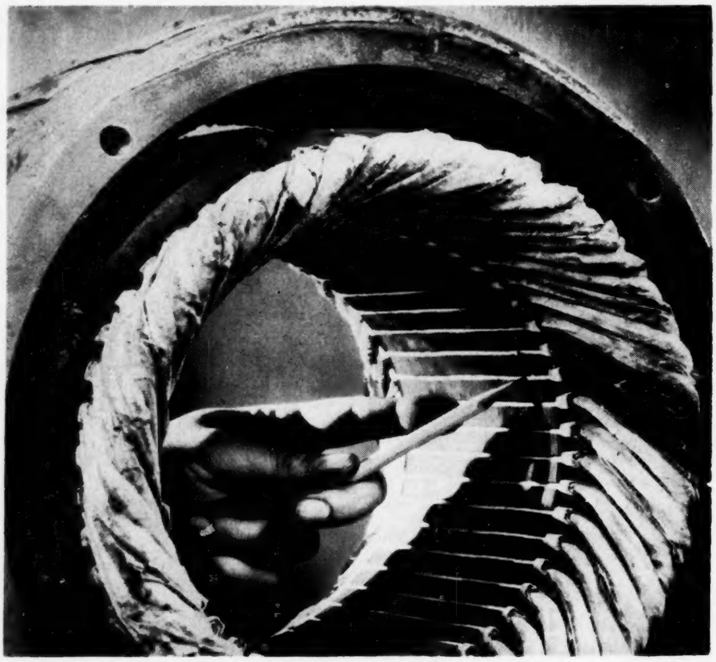
Synthetic gum: Du Pont will build a new plant at its Carney's Point, N. J., works to manufacture refined as well as technical grades of sodium carboxymethyl cellulose. Existing unit, producing technical grades of sodium CMC since 1947, will be dismantled when new plant is completed early next year.

Polystyrene: Japan this spring has two plants producing polystyrene: Monsanto-Kasei plant near Nagoya, and Asahi-Dow unit near Yokohama. Dow Chemical Co. early this year shipped 1,500 long tons of styrene from Freeport, Tex., to Yokohama for conversion to the polymer.

Isopropanol: Shell Chemical Corp. announced plans to up production of isopropyl alcohol by 120 million lb./yr. Shell will expand in two steps: by 70 million lb./yr. in 1957, 50 million lb./yr. in 1958.

Tin, tungsten: Wah Chang Corp., which recently bought the Texas City tin smelter (only one in the U. S.), will sink sizable capital in equipment to make tungsten and tin alloys there.





SILICONE insulation still functions after 60,000 hr. at 464 F.

At 220 F., This . . .

Motor Varnish Will Last 5,000 Years

It retains insulation resistance, bond strength, water repellency, as severe tests near completion.

Test motor which was started up in Oct. 1943 to determine maximum life of its silicone insulation has finally broken down—for physical reasons not related to insulation. After 60,173 hr. at 464 F., the equivalent of 360 yr. at standard Class H hottest-spot (356 F.) temperature, or 5,787 yr. at conventional Class A (220 F.) limits, the silicone varnish still has good bond strength, insulation resistance and water repellency.

The test program, which originally involved eight motors, has yet to achieve its "maximum life" objective. Causes for breakdown of seven motors to date have been irrelevant and one motor is still in operation.

What the tests have achieved thus far includes:

- Understanding that failure mechanism of silicone insulation is far different than that of organic materials. Even after the varnish had crazed it still maintained a good bond, holding the other components in place. It never evolved into a conductor, because of its silica backbone. And it stayed hydrophobic.
- American Inst. of Electrical Engineers' recognition of silicone insulation as Class H (for "High temperature").
- Finding the minimum life, ie. the point at which crazing appeared on the varnish surface.

Original eight motors for the tests, a joint project of Dow Corning and Westinghouse Electric, were 10 hp., 1190 rpm., 3 phase induction units. Six units were insulated with silicone bonded and impregnated materials. For comparison, two were Class B insulated.

All eight motors were generator-loaded to produce average copper temperatures ranging from 392 F. to 590 F. Operating time at temperature was divided into heats, each a 25th of the motor's estimated maximum life. The heats were alternated with 24-hr. conditioning periods at 100% relative humidity. An abrupt drop in wet insulation resistance—the point at which crazing appeared on the varnish surface—would be taken as "minimum life." Actual insulation failure, of course, would be "maximum life."

It was anticipated that the test would run about a year or so. Both Class B units did fail and catch fire just about as expected, and the silicone insulated motors showed an abrupt drop in wet insulation resistance at the predicted times as well.

But contrary to expectations, the drop was not followed shortly by total insulation failure. Instead, the motors kept right on going. The 310-deg. motor, for example, was expected to fail within a week or so. It lasted over seven months. So did one of the 300-deg. motors, and the other held on for a year. When they finally did break down, it was due to copper oxidation, not to insulation failure.

The motor still in operation has already run longer at 464 F. than a Class A motor would be expected to run at 230 F., and it's still going strong.—**Dow Corning Corp., Midland, Mich.** 176A

Curing Agents

Easier to handle in curing epoxy resins.

Third of a series of dicarboxylic acid anhydrides—which are finding increasing use as curing agents for epoxy resins

Page number is also Reader Service code number

For more about any item, use the Reader Service Card

—has just been made available by National Aniline Div., New York. All three have physical characteristics which make for greater ease of handling during curing.

Called methyl Nadic anhydride, the newest compound is available in pilot plant quantities. Like its commercially-produced predecessors, dodecenyl succinic anhydride and hexahydrophthalic anhydride, it may be easily mixed with liquid epoxy resins at or slightly above room temperature or with solid epoxies heated only slightly above their melting points and stirred into the anhydrides. Methyl Nadic anhydride and DDSAA are liquids, HHPAA is a low-melting solid.

The compounds also have lower volatility under baking schedules than amines or phthalic anhydride, high heat distortion points and good strength properties. They permit use of higher filler loading, promote excellent electrical characteristics of cured castings. Methyl Nadic anhydride and HHPAA also show potential as plasticizers for alkyd resins.

Methyl Nadic anhydride's full chemical name is methyl endo-cis-biocyclo [2.2.1]-5-heptene-2, 3-dicarboxylic anhydride. Its molecular weight is 178, density is 10.3 lb./gal. 176B

Another company, Smooth-On Mfg. Co., Jersey City, N. J., has a new curing agent for epoxies, an acid anhydride called Sonite No. 21. Epoxies cured with this hardener are said to have heat distortion temperature up to 400 F., along with excellent electrical and physical properties and fire resistance. 176C

And a third company, Dow Chemical, has reduced its price of a curing agent—p,p'-methylenedianiline—from 74 to 54 cents/lb. MDA is also an intermediate in the making of methylene bis (4-phenyl isocyanate), one of the promising new diisocyanates being evaluated for use in polyurethane solid rubber elastomers. MDA price cut is expected to expand the market for MDI. 176D

Anti-TB Drugs

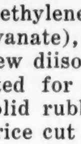
Two new drugs attack stubborn cases of tuberculosis.

A new antibiotic called cycloserine has been found effective against cases of tuberculosis which have not yielded to treatment with streptomycin, isoniazid and para-amino-salicylic acid (PAS). Another new drug called Nicotoben, a combination of isonicotine acid hydrazide with isonicotine aldehyde thiosemicarbazon at a ratio of four to one, overcomes the immunity which tuberculosis germs have developed against isonicotine acid hydrazides.

A patent on cycloserine and a method for making it by fermentation techniques has been granted to Chas. Pfizer & Co., Brooklyn, N. Y., and the company is about to begin marketing. In settlement of an interference before the U. S. Patent Office prior to the issuance of the patent, Pfizer licensed Merck and Commercial Solvents to manufacture, use and sell cycloserine. 178A

Nicotoben was developed by Farbenfabriken Bayer AG of Leverkusen, Germany. It can be used as the base product for any chemico-theraupeutical treatment of tuberculosis. 178B

For More Information...



about any item in this department, circle its code number on the Reader Service Postcard inside the back cover.

Organosol Formulation

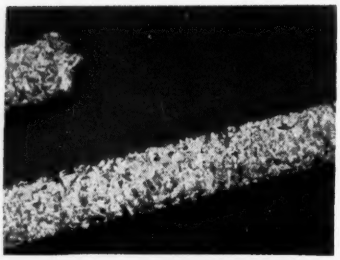
Makes for harder, more chemical resistant coating.

A versatile organosol formulation, based on Pliovic AO vinyl dispersion resin, has been developed for use in decorative and protective coating applications on metal surfaces. Formulated with 35 parts of plasticizer per 100 parts of resin, the coating affords a harder surface with less tack and greater chemical resistance than is possible with comparable formulations with higher plasticization.

Because of the inert nature of the vinyl resin, the coating is resistant to many acids, bases

and metallic salts, moisture and corrosive fumes.

The formulation provides flow characteristics specifically designed for metal applications and has excellent viscosity and dispersion stability. The coating may be brushed on or spray-applied.—**Goodyear Tire & Rubber Co., Akron 16, Ohio.** 178C



Crystal Bar Thorium

New process yields highest purity now available.

Orders for quantities up to ten pounds of the highest purity thorium now obtainable are being accepted by Metal Hydrides on the basis of its new pilot plant in Beverly, Mass. The crystal bar thorium product, magnified 1½ times is shown above.

Purity is of major importance to thorium's use as a fuel in atomic breeder reactors. Metal Hydrides' new high-purity grade is the product of the van Arkel-deBoer iodide process recently developed by the company in cooperation with Battelle Institute.

Product quality is typical of crystal bar metal, with oxygen less than 50 ppm., nitrogen less than 20 ppm., and carbon less than 40 ppm. Most metals below 2 ppm. are not detectable; the exceptions being aluminum less than 20 ppm., iron approximately 30 ppm., and copper less than 20 ppm.—**Metal Hydrides Inc., Beverly, Mass.** 180A

Synergist for Pyrethrins

Less toxic and cheaper in produce and animal sprays.

A newly-developed synergist for pyrethrins and related insecticides is said to be more effective and therefore to cost less to use than other available synergist formulations for equal knockdown and kill.

Called Sesoxane, it affords high kill without the use of DDT or other toxic insecticides. Comparison-tested on house flies with piperonyl butoxide, it achieved a 90% kill, vs. a 72% kill, in one day. Therefore it is expected that Sesoxane-pyrethrin formulations will be of special interest to formulators and packagers of insecticides where a safer product is required for use on grains, fruits and in household and animal sprays.

Chemically, the product is 2-(3,4-methylenedioxyphenoxy)-3,6,9-trioxaundecane. Because of its solubility in kerosene, Freon 11, Freon 12 and other solvents, it is easy to formulate in conventional equipment. It has a faint, pleasant odor and the low acute oral toxicity of 2,000 mg./kg. in rats.

Developed by the Dept. of Agriculture, it was recognized by Shulton, Inc., as an outlet for piperonal which the company already produced and which is the basic chemical required for the manufacture of Sesoxane. Using a company-developed process, the company now produces Sesoxane in pilot plant quantities. — **Shulton, Inc., 45 Rockefeller Plaza, New York, N. Y.** 180B

Heat-Resistant Plastic

Stable at temperatures as high as 550 F.

Excellent heat stability is the major claim of a chlorine-containing polyether called Penton. The new plastic can withstand fabrication temperatures as high as 550 F., and has a tensile strength of 3,000 psi. in boiling water (compared with a tensile strength of 6,000 psi. at room temperature). When an unsupported Penton valve is subjected to 60 lb. steam pressure at 320 F. for 18 months, dimensional stability is unaffected.

Aside from its unusual heat resistance, Penton also exhibits good wear resistance, resistance to hydrolysis in slight alkaline or acid media, low permeability, high tensile strength, resistance to sterilization, high clarity. This combination of properties suggest its use in such varied items as enclosed refrigerator motors, timing mechanisms, packaging film, rope.

Since the new plastic is still in the pilot-plant development stage, it's available only in experimental quantities. — **Hercules Powder Co., Wilmington 99, Del.** 180C

Plastics Colorant

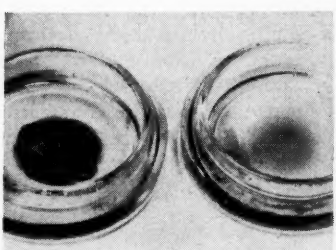
Red pigment exhibits outstanding fastness to heat and light.

A new organic red pigment specially developed for coloring plastics — especially polyvinyl chloride—is said to have the edge over most inorganic reds.

Called Irgalite Red HGL, the new pigment claims outstanding fastness to light and heat even when used in low concentrations needed to produce tint transparencies. In fact, it gives pigmentations of exceptional fastness to light and heat when used to produce both transparent and opaque tint shades.

Like other colorants, HGL's shade and properties are somewhat affected by different plastics, plasticizers and stabilizer systems. But variations of pigmentation are slight.

Chemical composition of the new colorant bars its use in rubber compounds.—**Geigy Co.. Rhodes, Middleton near Manchester, England.** 180D



Lubricant

Exposed to high heat, new oil—right—does not leave typical residue.

Drastic tests such as the one pictured above have demonstrated the ability of a new lu-

bricant to protect machinery operating at high temperatures. Called Keystone No. 49 Light, the new compound (right) and a conventional compressor oil (left) were baked in thermostatically controlled ovens for 72 hr. at 300 F. As shown, the conventional oil evaporated and carbonized, whereas Keystone No. 49 Light remained liquid and free of carbon.

Developed primarily for air compressor use, its low carbon content and anti-gumming features make it a superior lubricant for such applications as ring bearings in electric motors, multi-plate friction clutches, plastic molding heat transfer systems, drying oven conveyor chains, textile tenter frames. Severe laboratory and field tests have proved that Keystone No. 49 Light resists oxidation, sludging and breakdown.

Some specific physical properties: carbon residue (Conradson), 0.33%; viscosity index, 96 sec.; pour point, −5 F.; cold test, −10 F.—**Keystone Lubricating Co., 3100 North 21st St., Philadelphia.** **180E**

Irradiated Poly

Excellent thermal properties prompts hike in volume, variety.

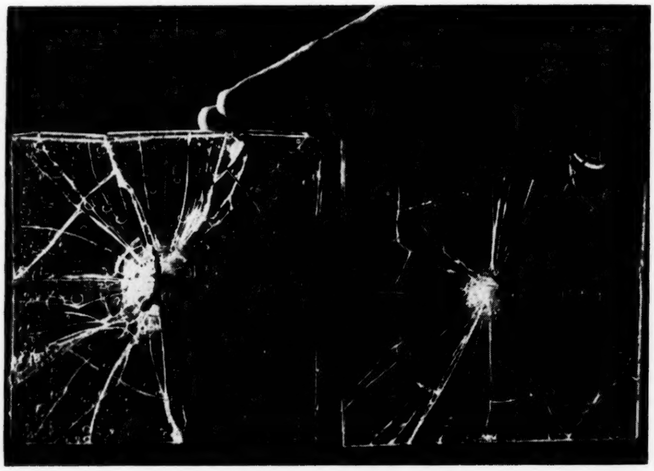
Moving from pilot research to full-scale production in less than three years, General Electric plans to increase production capacity for its irradiated polyethylene, Irrathene, from 300,000 to 1.6 million lb./yr., with provisions for a further doubling of the latter capacity. Thus far, Irrathene shares the commercial horizon with only one other product of electron radiation: Sequoia Process Corp.'s Hyrad, irradiated polyethylene produced as a coating on wire (*Chem. Eng.*, Aug. 1956, p. 122), for which exclusive process rights have recently been sold to W. R. Grace.

Initial marketing of Irrathene, produced as a tape in three different formulations and two types, has been in the electrical insulation field. But its properties give it an almost certain future as protective packaging, encapsulation of small coils and parts, sacrifice films and tapes, base for pressure sensitive tape, release films, protective pipe wrap. Combination of chemical resistant and thermal properties excels that of conventional polyethylene and is unique in many ways.

By proper selection of irradiation dose—which causes the characteristic cross-linking of the Irrathene polymer—and by building in controlled orientation, GE has aimed at developing a product which is non-melting, heat shrinkable and heat sealable. Conventional polyethylene softens around 165 F. and melts at about 230 F. Irrathene, in sealed systems or in the absence of oxygen, can withstand temperatures up to 392 F. with little change in its excellent mechanical or electrical properties over prolonged exposure periods. Overload protection against short exposure up to 482 F. is also provided.

When properly applied Irrathene tapes and films can be used to provide a form fitting sheath of insulation which is practically impervious to moisture and conducting dust. Some grades of Irrathene tape shrink up to 50% of their initial lengths. If these tapes are wound on solid objects, the shrinkage is translated into a shrinkage force which causes the tape to conform to the shape of the object to be insulated, and also causes the layers of insulation to seal together. Irrathene tapes and films can also be heat sealed using conventional heat sealing equipment.

Because of oxidation, unstabilized polyethylene degrades in a matter of hours at temperatures above 212 F. For some grades of Irrathene, selection

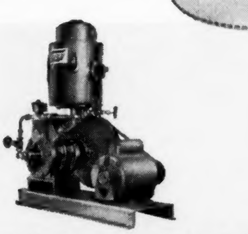


Silicone-Filled Windshield, Right, Stands Jet Heat

A new silicone rubber to serve as center layer in safety glass windshields for supersonic aircraft has been developed by Dow Corning in conjunction with Wright Air Development Center. Called Silastic Type K, it retains full strength and clarity at temperatures ranging from −65 to over 350 F. and will even withstand hours at 375 F., above right.

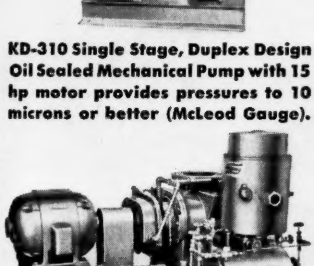
In conventional plasticized polyvinyl butyral laminate, left, inner layer softens, bubbles and oozes out the panel edges after a few minutes at 375 F., robbing the windshield of shatter resistance.—Dow Corning Corp., Midland, Mich. 182B

NOT ONE, BUT TWO SLICES off your operating costs



KS-13 Single Stage, Simplex Design KINNEY Oil Sealed Mechanical Pump with ½ hp motor produces pressures to 10 microns (McLeod Gauge).

KD-310 Single Stage, Duplex Design Oil Sealed Mechanical Pump with 15 hp motor provides pressures to 10 microns or better (McLeod Gauge).



KMB-1200 KINNEY Mechanical Booster High Vacuum Pump with 10 and 5 hp motors produces ultimate pressures to 0.1 microns (McLeod Gauge).

with Kinney®

HIGH VACUUM PUMPS

You don't have to wait for KINNEY Pumps to "warm up" to their job of pumping a High Vacuum . . . pump-down starts with the first revolution. Power consumption is lower per cubic foot evacuated and time of pump-down to operating pressures is shorter. This means savings in time, and power. And—KINNEY Pumps use *less* horsepower holding a vacuum—even in the 1 micron range or lower. These are two important savings whether you are dehydrating, deaerating, distilling, fumigating, freeze-drying, separating, refining, purifying or employing any other of a thousand and one Vacuum processes. KINNEY Pumps slice costs and are unique in their ability to perform constantly with minimum maintenance.

COMPLETE HIGH VACUUM SYSTEMS

KINNEY-built High Vacuum Systems range from laboratory and research units, reaching for pressures in the order of 10^{-7} mm Hq. or lower, to pilot plant and full scale custom-tailored production equipment.

For the Metallurgist there are units for Evaporating or Sputtering, as well as large scale Degassers, Heat Treating, Sintering and Melting Furnaces. KINNEY Engineering, backed by half a century of Vacuum "know-how," offers YOU extra advantages in the perception of your Vacuum problems and the development of equipment to best solve them!

WRITE:
for Bulletin No. 425 and special information on new developments in KINNEY engineered High Vacuum equipment.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3551C WASHINGTON STREET BOSTON 30 • MASS.

Please send me copy of your Bulletin No. 425 ☐. We would like to discuss equipment for________________
________________☐

Name________________

Company________________

Address________________

City________________Zone______State________

of proper anti-oxidants has extended aging life at, for example, 302 F. to almost 10 weeks.

In addition to the six commercially-produced grades, there are several available in experimental quantities:

- Irrathene SC is a highly carbon black loaded polyethylene with an electrical resistivity intermediate between a true insulator and a true conductor. Its development was made possible by the ability of irradiation to overcome the embrittlement of polyethylene when large amounts of filler are loaded in it. It has been designed to replace such materials as graphitized fabrics and rubber. The fact that it is made from a polyethylene base makes it attractive for building an all-polyethylene insulated cable because it will be compatible.
- Irrathene E-234, an extrudable preirradiated polyethylene, offers the user a convenient way of insulating wires with a polyethylene coating that is form stable and which has excellent stress cracking resistance. Normally, irradiated polyethylene is not processable because of the cross-linked three dimensional nature of the material. But E-234 can be extruded onto wire in the same fashion as polyethylene with only slight modifications in conditions.—**General Electric Co., Pittsfield, Mass.** 182A

PVC Resins

Better heat stability eases quality control and processing.

With a molecular weight range geared for easy processing, a new line of general purpose polyvinyl chloride resins has been developed for use in calendering, extrusion and molding industries. Outstanding characteristic of the line is improved heat stability with its advantages in quality control and processing.

Commercially produced at a new plant near Pensacola, Fla., charter members of the line are: Escambia PVC 1250, a high molecular weight resin, recommended for extrusion of shapes and profiles and for calendered film; an intermediate molecular weight resin, 1225, is particularly adapted for supported and unsupported sheeting; the lowest molecular weight resin in the series, 1200, is designed for flexible and rigid sheeting.—**Escambia Chemical Corp., 261 Madison Ave., New York, N. Y.** 184A

Expandable Polystyrene

New extruded form makes lightest rigid insulation yet.

A new extrusion process developed for use on Koppers Co.'s expandable polystyrene yields foam of greater compressive strength in ratio to weight than any other insulating materials —a norm of approximately 20 lb./sq. in.

Extruded slabs are available in a width of 2 ft., thicknesses ranging from ½ in. to 10 in. and at any desired length. This, coupled with light weight, permits the reduction of joints in a given insulating structure through convenient use of large size slabs and sheets—sizes, in fact, that would be prohibitive on the basis of weight and cost for other types of insulating materials. Biggest markets are expected in cold storage warehouses, refrigerated trucks and railroad cars, sectional refrigerators, for general building construction. — **Dyfoam Corp., New Castle, Pa.** 184B

BRIEFS

Polyvinyl acetate emulsion with excellent water resistance, trademarked Elvacet 84-1100, is now commercially available. Designed primarily for use as a vehicle in water-base paints, its stability and water resistance offer advantages in either exterior masonry paints or interior paints. Priced at the same level as existing homopolymers, it is also expected to find use in adhesives, paper coatings and textile finishes.—**Du Pont Co., Wilmington 98, Del.** 184C

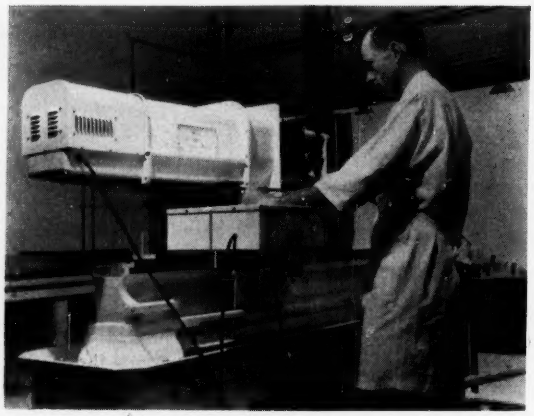
Piperazine, ordinarily a high melting solid that is quite hygroscopic and requires great care in handling, is now available as a eutectic mixture containing about 40% water, melting at about 95 F. —**Carbide & Carbon Chemicals Co., 30 East 42nd St., New York.** 184D

Broad-spectrum antibiotic, a new salt of tetracycline, is said to greatly excel the conventional hydrochoride salt. For instance it has been shown that blood levels from a single oral dose of the new Tetrex are almost double those from an equal dose of tetracycline hydrochloride.—**Bristol Laboratories Inc., 630 Fifth Ave., New York.** 184E

Unsymmetrical dimethylhydrazine, a strong reducing agent used as an aviation fuel, oxygen scavenger and anti-skinning agent in paints, is now available commercially. A colorless, hygroscopic liquid, it has an amine-type odor, a boiling point of almost 150 F., freezing point of about −70 F., and specific gravity of 0.782. — **Olin Mathieson Chemical Corp., 460 Park Ave., New York.** 184F

PROCESS EQUIPMENT

EDITED BY C. S. CRONAN



CAMERA copies line work up to 36 x 54 in. per shot.

PROJECTOR in drafting room makes tracing easy.

New Photo System Shrinks Drawing Files

Either clear or muddy engineering drawings are reproduced accurately and clearly by photos. Stored on small file cards, they reduce storage space 96%.

An entirely new photographic system for reproducing engineering drawings is just being introduced as a nationwide service, available in 40 major cities throughout the United States and Canada.

Using 105 mm. film with 16 times the area of conventional 35-mm. microfilm, the Micro-Master system produces sharp, clear and distortion-free second originals up to 36 x 54 in. size. Yet, the negatives are sufficiently small to fit standard 5 x 8-in. card-file drawers which occupy only 1/25th the space needed for an equal number of tracings.

▶ **Tested Exhaustively**—During field testing of the Micro-Master process, over ½ million negatives have been produced. More than 50,000 of these were for the Corps of Engineers, U. S. Army, which is well along with an extensive program to transfer its huge tracing files to film. At least 14,000 drawings already have been replaced by the photo copies.

Trans World Airlines will use Micro-Master for the 30,000 drawings that detail every part and assembly of the carrier's new Lockheed 1649 Super Constellation transport. TWA estimates that the full set will require only 15 sq. ft. of storage and operating space compared to 392 sq. ft. needed for the equivalent blueprints. And the 105-mm. negatives will cost only half as much as full-sized reproductions on paper.

▶ **Several Tools in Kit** — The 105-mm. negative produced by the Micro-Master system may be used in several ways.

It can be stored in its transparent protective sleeve and kraft envelope for future reference. Where positives are preferred, economical 4 x 6 in. contact card prints can be furnished for separate filing and indexing.

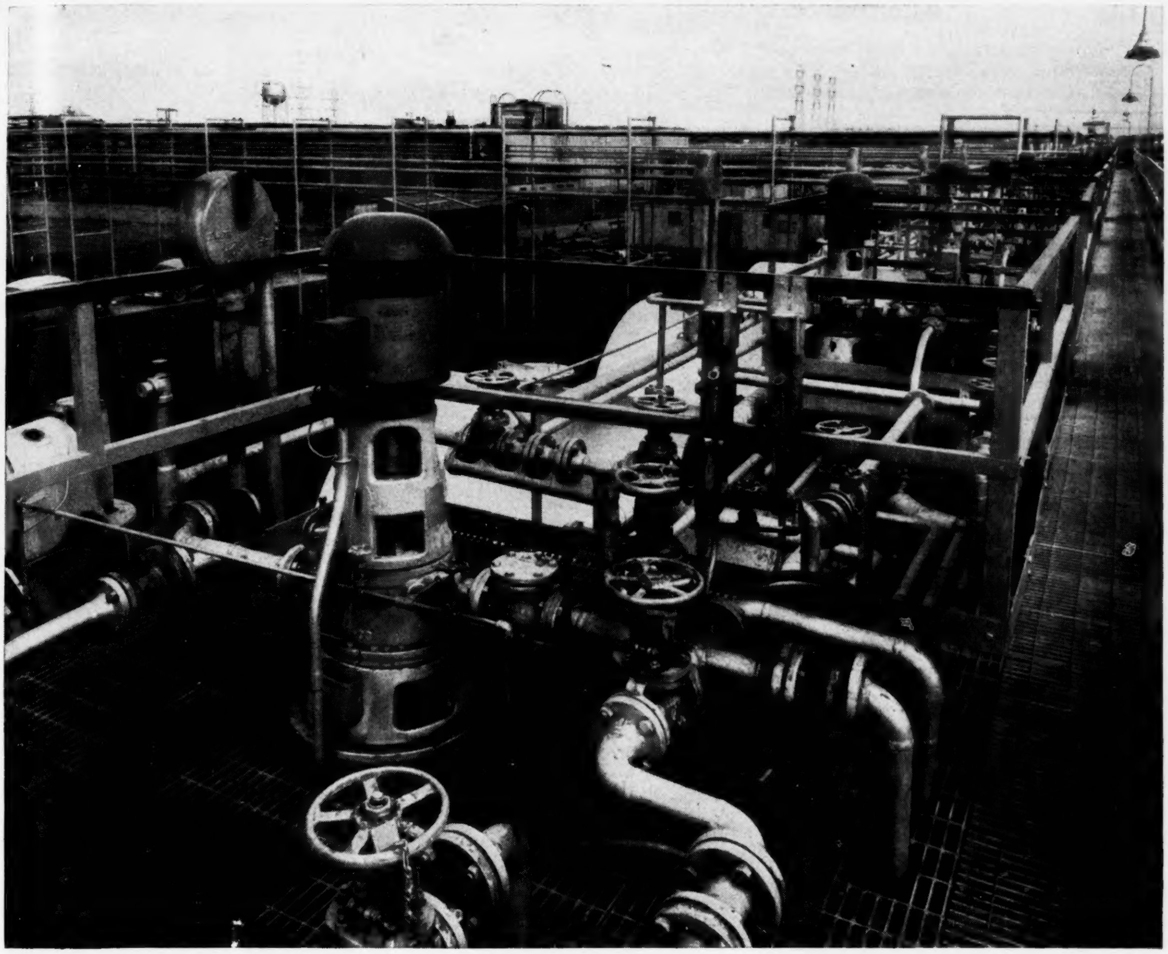
Or, you may wish full-sized second originals which can be produced on a choice of transparent or opaque bases. These are reported to be consistently higher quality than the true originals.

For quantity duplication, offset plates can be prepared directly from the negative with substantial savings both in time and money.

In the drafting room, the negatives are used with Micro-Master accessory equipment such as fully engineered screen projector, table-top viewer with 8 x 12-in. surface or large-size viewing table (see illustration).

▶ **From Dirty to Clean**—By conservative estimate, two thirds of all engineering and architectural drawings on file are either difficult to copy or illegible when reproduced. That is why for years blueprinters have tried to reproduce or repair these faded, torn or soiled drawings without the extremely high cost of retracing them line by line.

Conventional copying on blueprint, diazo or reflex papers cannot solve the problem because light that passes through the original emphasizes faults, ne-



After nine years and thirty million gallons...

This plant of B.F.Goodrich Chemical Company at Avon Lake, Ohio, went into operation in 1948. There were 12 LaBour Type G pumps in the original installation, and by conservative estimate they have pumped something like 30,000,000 gallons of alcohol, plasticizers and blending liquids. All are still on the job 24 hours a day, and total repairs for the lot consist of a few bearing replacements. Since Type G is a packingless pump there has been no packing expense.

When a recent expansion was planned to add materially to the capacity of the plant it was decided not to buy any more pumps. The nine-year-old LaBours had demonstrated such dependability and were in such good condition that they could be trusted to handle the increased responsibility without help.

If you're looking for real economy in pumping, consider this typical LaBour performance record. Difficult jobs and difficult liquids make it even more profitable to assign the task to LaBour. Ask us to prove it.

ORIGINAL MANUFACTURERS OF THE SELF-PRIMING CENTRIFUGAL PUMP

LaBOUR

THE LaBOUR COMPANY, INC. • Elkhart, Indiana, U.S.A.

Page number is also Reader Service code number

For more details, use Reader Service Card

cessitating extra art work. And previous photo methods fall short because of optics limitations or the fact that conventional photographic equipment and techniques cannot selectively reproduce desired linework.

To overcome all these shortcomings, the Micro-Master system combines new optics systems with techniques that are meticulously precise. Control of developing and printing is equivalent to that used for color photography.

When a tracing is to be reproduced, it is mounted on a vacuum easel and photographed to pick up maximum detail including soiled areas. Thus, the weakest line image is captured without respect to background dirt. Soil and mottle then are clipped out of the projected image with exposures which are timed precisely to the nearest tenth of a second required for a clean picture.

The developed and dried 105-mm. negative provides a perfect pin-hole-free image of all line work. No corrective opaquing or artwork is needed except to delete unwanted features of the drawing itself.—**Keuffel & Esser Co., 260 Madison Ave., New York 16, N. Y.** **186A**

Remote Viewer

Shows interior of consumable-arc furnaces.

During production of titanium and other new metals, the operator can view the operation with complete safety through new **remote viewer.**

Viewer fits over the viewing port of the consumable-electrode furnace. Operator can stand outside a concrete barrier and study the electrode image on an 8-in. ground-glass screen through a safety glass window. Downward travel of the electrode can be observed to a maximum distance of 10 ft.

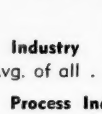
This viewer is offered at comparatively moderate cost because preliminary design work was done in connection with original units installed at Electro Metallurgical Co., Niagara Falls, N. Y.—**American Optical Co., Special Products Group, Instrument Div., Buffalo 15, N. Y.** **188A**

Equipment Cost Indexes

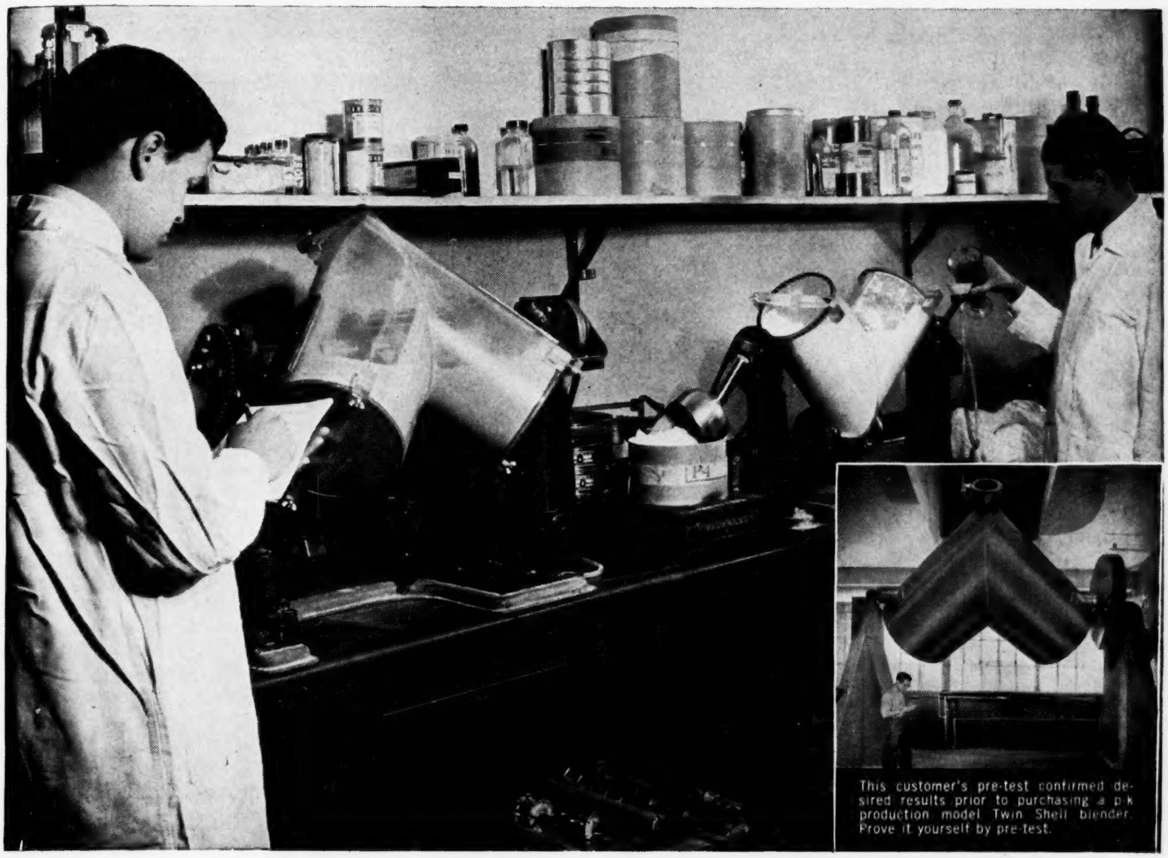
	Sept. 1956	Dec. 1956
Industry		
Avg. of all	211.3	218.3
Process Industries		
Cement mfg.	201.6	208.6
Chemical	211.5	218.8
Clay products	195.8	202.6
Glass mfg.	199.8	206.7
Paint mfg.	203.5	210.5
Paper mfg.	203.8	210.9
Petroleum ind.	207.7	214.9
Rubber ind.	210.3	217.6
Process ind. avg.	209.0	216.2
Related Industries		
Elec. power equip.	213.4	220.8
Mining, milling	212.8	220.2
Refrigerating	237.3	245.9
Steam power	199.2	206.1

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See *Chem. Eng.*, Nov. 1947, pp. 124-6 for method of obtaining index numbers; March 1956, pp. 194-5 for annual averages since 1913.

For More Information...



about any item in this department, circle its code number on the Reader Service Postcard inside the back cover.



This customer's pre-test confirmed desired results prior to purchasing a p-k production model Twin Shell blender. Prove it yourself by pre-test.

Pre-Tests "Guarantee" Performance of P-K Twin Shell Blenders*

There's never a question as to whether a p-k Twin Shell Blender will do the job. For p-k's "pre-test" service, described at right, removes all guesswork and *proves* that a p-k blender will give you the results you need . . . whether it be a standard model Twin Shell for gentle mixing action, an "Intensifier"* model for difficult-to-blend materials, or p-k's new "Liquid-Solids"* blender, designed for blending liquids into dry materials.

Actually this blending pre-test of your materials is just an extra safeguard. For p-k's remarkable Twin Shell blenders . . . with their unique blending action . . . probably have *already* proved their effectiveness on a job like yours.

Take a look at the V-shape of the shell. In every revolution there's a 5-way tumbling and mixing action *that you can't duplicate in any other blender*. Blending is fast, thorough, and results are consistently uniform.

Add to this the fact that clinical cleaning is a snap in the smooth, baffle-free, interior . . . that loading and discharge is simplified through the ample openings . . . that maintenance is negligible . . . and that blending results obtained with any p-k lab model (from 1 pint working capacity up to 8 quarts) scale-up to production sizes.

*Patented and Patents Pending

Investigate P-K's Blending Concept

P-K's Customer Service Laboratory will be pleased to test-blend your materials . . . preferably under your supervision. Material formulations will be blended to your exact specifications and returned for analysis, together with a complete report. P-K recommends pre-tests for all "Liquid-Solids" applications, because of the many variables that may effect blending procedures necessary for intimate dispersion of liquids in solids. Our Lab also conducts comparison tests in pilot models of all other basic blender types . . . from ribbon and double cone to p-k's standard Twin Shell and "Intensifier" models.

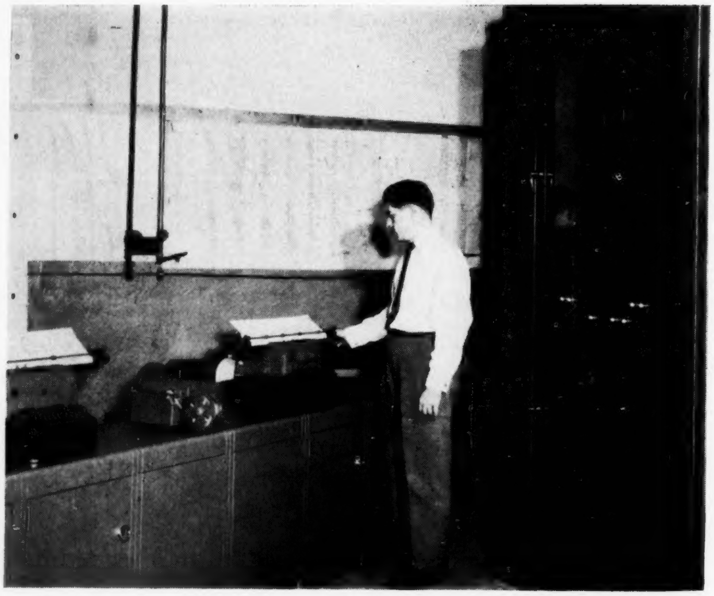
All of them are members of a growing family of p-k blenders and all are described in our new catalog 14. Write our Mr. R. T. Dotter for your copy . . . and arrange, too, for a pre-test of your materials.

The Patterson-Kelley Co., Inc., 130 Hanson St., E. Stroudsburg, Penn.

Patterson Kelley

Chemical and Process Division

P-K Twin Shell Blenders* • Heat Exchangers • Packaged Pilot Plants • P-K Lever-Lock Doors*



Computer Built Into Cat Cracker

Analog device calculates process information to tighten process control, guide crews to more efficient operation.

For the first time, a programmed general-purpose analog computer will become an integral element of oil refinery process control at the Belot Refinery of Esso Standard S. A. near Havana, Cuba. Installation in a Model IV fluid catalytic cracker is scheduled for completion during the Spring of 1957.

▶ **Tightens Control Loop**—Each hour, the computer will provide the operating crews with information needed to supervise and analyze conditions in the refining unit. Units can be run more efficiently than is possible by conventional manual calculation.

While computers have been used previously by refineries, they have been located only in central offices. It has been necessary for engineers to inspect units regularly, obtain data by various calculations and feed these facts back to the computer in the office.

Now, the engineer obtains data from the computer and printer on the spot merely by pushing a button. Or, he obtains it as delivered by the computer on the regular hourly programmed cycle.

▶ **Handles and Computes**—Designed by Fischer & Porter Co., the system is known as a Coordinated Automatic Data Logger and Computer. It will record key refining process variables such as temperatures and pressures.

Using this information, the device calculates 11 so-called "operating guides" and records them on the log sheet. These guides are fundamental process control information such as the rates at which carbon burns and catalyst circulates.

Among the system's features are two electric typewriters that punch all data on paper tape, with proper identification and keying for storage and accounting analysis on business machines. In addition to logging 101 process variables on the timed program, or on demand, the equipment automatically totalizes and records every 24 hr. the major process quantities derived from these variables.

All equipment, except the typewriters, will be housed in three cabinets each measuring about 5½ x 7½ x 2 ft. Typewriters will be mounted separately on a console desk.—**Fischer & Porter Co., 960 Jacksonville Rd., Hatboro, Pa.** 190A

Temperature Control

New dual-range models extend operating range in both directions.

Two new dual-range thermistor-actuated temperature controllers appreciably extend range and permit use of these instruments for sub-zero applications for the first time. Total coverage is from 100 to 600 F. for Model 56006 and from −100 to +150 F. for low-range Model 56007.

Temperature control with thermistors is said to offer advantages in accuracy and stability of control. The large change in resistance per degree of temperature change allows these controllers to deliver 0.25% control accuracy over the entire range. Instrument operates for several months without need for recalibration. When needed it is done simply with a screwdriver. — **Fenwal, Inc., Ashland, Mass.** 190B

Flue-Gas Monitor

Determines excess air by measuring O_2 content.

A new flue-gas monitoring system analyzes O_2 content as a measure of excess air and adjusts fuel-air ratio automatically to maintain optimum combustion. It can be used on a broad range of combustion equipment, including powerplant boilers, process heaters, cement kilns, SO_2 burners and steel open-hearth furnaces.

Careful design of the sampling probe, gas-cleaning unit and analyzer provide high re-

New *Tri-Sure*® Plant in Australia

the latest link in

TRI-SURE THE WORLD OVER

The new Tri-Sure Plant at Villawood, N. S. W., Australia

Now made in Australia, too!

Tri-Sure
FOR DRUMS

Tri-Sure
FOR PAILS

The Sign of  a Perfect Seal

Tri-Sure* Closures for drums and pails are now being manufactured in this modern new plant just outside of Sydney, Australia—the latest advance in Tri-Sure's world-wide program.

This new plant provides Far East industry with a fast, efficient source of supply of Tri-Sure Flanges, Plated Steel Plugs, Die Cast Plugs and Cap Seals for Drums, as well as Tri-Sure Nozzles and Caps, and Push-pull Spouts for Pails. In addition it offers closure users in that area the *quality* gaskets that are so vital to dependable closure performance.

This newest Tri-Sure plant underscores what is widely recognized among closure users all over the world: wherever *your* plant is located, there is a Tri-Sure plant, and engineer, to serve you—and Tri-Sure Closures that will best serve the needs of your products.

*The "Tri-Sure" Trademark is a mark of reliability backed by over 35 years serving industry.

Always specify

Tri-Sure

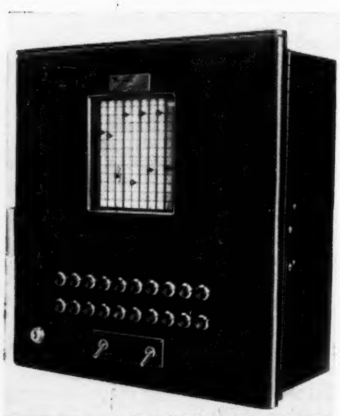
CLOSURES

AMERICAN FLANGE & MANUFACTURING CO. INC., 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.
CHICAGO, ILL. • NILES, OHIO • LINDEN, N. J.
Tri-Sure Products Limited, St. Catharines, Ontario, Canada
Tri-Sure S/A Indústria e Comércio, Sao Paulo, Brazil
American Flange & Manufacturing Co. Inc., Villawood, N.S.W., Australia
B. Van Leer N. V., Stadhouderskade 6, Amsterdam, Holland
Van Leer Industries, Ltd., Seymour House, 17 Waterloo Place, Pall Mall S.W. 1, London, England

sponse speed; ability to handle dirty, high-temperature flue gases; continuous operation with minimum maintenance; and means of obtaining a true average sample where O_2 content varies with location in flue.

Gas sample is drawn through a probe by suction from a steam-jet ejector. Three reverse jets of water keep the probe head clean.

Gas is cleaned by a jet condenser and centrifugal separator, then passes through a condensate separator and filter to the analyzer. Oxygen content is measured through the paramagnetic properties of O_2. Oxygen content of the gas is compared to that of the atmospheric air, producing a signal proportional to the oxygen content of the flue gas.—**Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.** **190C**



Pyrometer Controller

Controls temperature of several individual units.

With one multi-point, pyrometer controller you can control automatically the temperature of four to 10 separate units. Instrument combines the accuracy of a null-balance potentiometer measuring circuit with the speed of an electronic control system.

Controller applies to almost any installation suitable for two-position control action. A pulse timer and selector switch connects thermocouples in sequence to the master control unit.

This unit compares each thermocouple unit to its set point and energizes or deenergizes the corresponding load relay to the process unit. Usual operating speed is 3 sec. per point.—**Thermo Electric Co., Inc., Saddle Brook, N. J.** **192A**

Sonic Gas Analyzer

Is rapid and sensitive over exceptional range.

A new gas analyzer uses sound waves to monitor gas mixtures, detect minute amounts of harmful gases, measure gas fractions in chromatography, and study isotope concentration in certain gases.

Wide differences in sonic velocity are exploited by the analyzer to achieve sensitivities such as 0.005% O_2 in air and 0.00061% H_2. Sensitivity remains high over the entire range from 0 to 100%.

Gas is fed into the sonic measuring tube at its center, then flows in both directions to the ends. With such an arrangement, rate of sound transmission is not changed by velocity of flow.

Sound waves generated at one end of the tube are received by a crystal transducer at the other end. Phase of the 150-kc./sec. signal is compared with that of the generating crystal. Phase shift in the signal is a precise measure of the change in sound velocity related directly to the gas composition.—**National Instrument Laboratories, Inc., 6108 Rhode Island Ave., Riverdale, Md.** **192B**

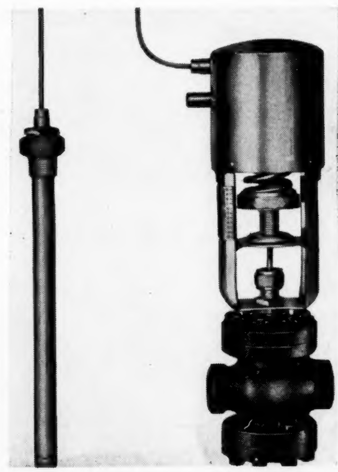
Thermocouple Link

Provides multiple connections, installs easily.

Multiple thermocouples can be connected manually to an instrument with the new Quik-Konnect components. They are easy to use and foolproof. Installation time is cut 75% and easily lost small parts no longer need to be handled.

Components consist of Fiberglas reinforced phenolic plastic plugs, jacks and phenolic-plastic multiple-jack panels with tube connectors and cable clamps for mounting.

Plug and jack assemblies are marked to identify the type of thermocouple with which they should be used. They come equipped with inserts or points made from the thermocouple alloy to which they should be connected. These inserts and points have different diameters for positive and negative poles so you can make the connection properly. — **Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Philadelphia 44, Pa.** **192C**



Temperature Regulator

Constructed of stainless steel for chemical service.

Developed mainly for use in chemical plants, regulator 11061-R withstands the corrosive effects of certain fumes, gases, acids and chemicals.

Standard models of this control have upper works entirely of stainless steel. For extremely corrosive conditions, valves as well as the upperworks can be furnished in stainless steel.

In common with manufacturer's other regulators, new unit requires no external power source to function efficiently. A large stainless-steel bellows is used in the thermal unit to provide accurate sensitive control of temperature. — **Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville, Tenn.** **192D**

The lightweight, rugged Yale Zephyr is a push or pull hand lift truck—specifically built to speed handling of lighter loads which cannot be moved efficiently by hand. Its compact design allows the Yale Zephyr to work in narrow aisles and crammed quarters with amazing speed and ease. A single-action treadle controls lifting and holds the load. Depressing the treadle will not lower the load until the operator pulls the handle into position for balancing the weight of the load—an extra safety feature. Steering is easy with a rubber-tired caster front wheel that rotates on roller bearings with a double race bearing swivel.

Used alone or as an integral part of your materials handling system, Yale Zephyrs speed short-distance hauling, save time wherever materials in quantity must be moved and cut operator effort in handling heavy and awkward loads. For complete information on the Yale Zephyr or other Hand Trucks in capacities from 1,000 to 12,000 lbs., write The Yale & Towne Manufacturing Co., Philadelphia 15, Pa., Dept. A-443.

YALE* INDUSTRIAL LIFT TRUCKS AND HOISTS

*REG. U.S. PAT. OFF.

Gasoline, Electric & LP-Gas Industrial Lift Trucks • *Worksavers* • Warehousers • Hand Trucks • Hand and Electric Hoists

Aluminum Pipeline

Installed on gas transmission line service.

Nearly four miles of unprotected Schedule 40, 8-in. aluminum pipe has been installed as part of the gas transportation system servicing Alcoa's Point Comfort, Tex., operations. High corrosion resistance of the aluminum pipe is expected to provide long, efficient, low-cost service.

Pipe is buried in soil ranging from sand and gumbo to salty marsh. Completely devoid of protective coatings and anodes, the line is shielded only by electrical insulation at certain flanged joints.

Line was installed by joining 40-ft. lengths of pipe by argon-shielded tungsten arc and consumable electrode welding methods. Gas pressure in the line is 500 psi.—**Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.** 194A

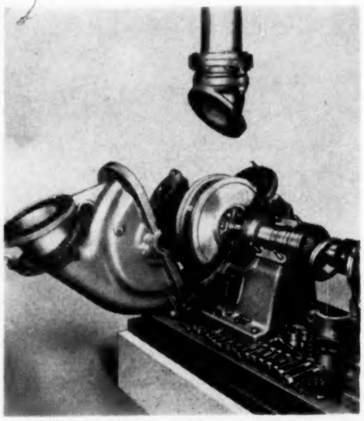
Gas Filter

Removes suspended material from gas streams.

A new high-pressure gas filter cleans gas streams of suspended material to protect equipment such as turbine expanders, compressors, pumps, nozzles and blowers.

When tested with U. S. Standard Fine Test Dust the resin-impregnated filter elements are 99% efficient. Convoluted shape of the elements provides extended area. On particularly hazardous or damaging dusts two filter elements can be used in series for maximum protection.

For heavy duty application, the elements are protected by an expanded metal outer cover and mounted in housings that meet ASME Boiler and Pressure Vessel Code. Each unit is engineered to the requirements demanded by the particular application.—**Purolator Products, Inc., Rahway, N. J.** 194B



Hinged Pump Casing

Reduces downtime and maintenance effort.

A hinged cover casing with jacking bolts has been developed to save time and effort when removing upper half of centrifugal pump casing to check or remove the rotating element.

Here you see how this design permits easy opening of a Goulds pump, Fig. 3135.

When bolts between discharge elbow and upper half of pump casing have been removed, the discharge elbow is telescoped into discharge connection by means of jack screws. This provides clearance and preserves gasket.

Once parting bolts that connect upper and lower half of casing have been removed, the upper half is raised by loosening nuts on hinge pins and using the jack screws. Then casing can be pulled fully open with chain fall.—**Goulds Pumps, Inc., Seneca Falls, N. Y.** 194C

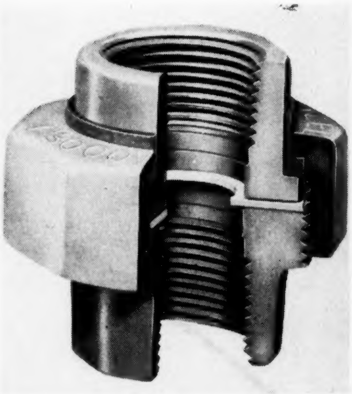
Fog Nozzles

Non-clogging and corrosion-resistant with most fluids.

A new line of hard-rubber fog nozzles is claimed to be non-clogging, corrosion resistant with practically any spray, long wearing and inexpensive to use.

These nozzles are considered ideal where metal would corrode and where other non-metallics are hampered by chemical properties, high temperature or cost. Nozzles in this HR series have one-piece, non-clogging construction with exclusive spiral design.

Ten models are available with narrow angle (50°) or wide angle (120°) hollow-cone spray pattern in five different flow rates from 5 to 50 gpm.—**Bete Fog Nozzle, Inc., 309 Wells St., Greenfield, Mass.** 194D



Insulating Union

Prevents electrolytic corrosion of pipelines.

Insulating forged-steel unions are now available to prevent electrolytic corrosion due to flow of electric current along pipelines.

Tailpiece, thread piece and nut are drop forged from carbon steel. Insulating sleeve that separates tail piece and nut is fabric-reinforced phenolic resin. Gasket which seals the union joint and which contacts fluid in the pipe, is Teflon.—**W-S Fittings Div., H. K. Porter Co., Inc., P. O. Box 95, Roselle, N. J.** 194E

Efficient new pipe covering for outdoor or indoor lines operating up to 1800° F.

Kaylo-20*, a new, highly efficient pipe insulation for service at all temperatures to 1800° F:, is made to fit pipes as large as 39″ in diameter. High flexural strength (50 lbs/in^2) and compressive strength (100 lbs/in^2 at 5% deformation) plus light density (12 lbs/ft^3) reduce breakage during installation and service, allow easy fabrication. Kaylo-20 is moisture resistant and dimensionally stable, keeps its high strength and efficiency with negligible shrinkage and warpage even under severe service conditions. Outdoors, weatherproof finishes are easily applied. Kaylo-20 is made to simplified dimensional standards, in 3′ lengths, 1″ to 3″ thicknesses.

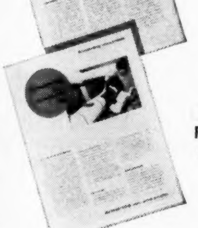
Kaylo-20 is one of the many quality products in the full line of Armstrong Industrial Insulations. Armstrong also offers you a complete contracting service, geared to install these products economically and efficiently.

For full data on Kaylo-20 or any other Armstrong insulations, send for free booklets. Check the ones you want on the coupon below.

* T.M. Owens-Illinois Glass Co.

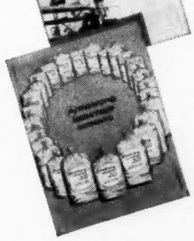
Armstrong
INDUSTRIAL INSULATIONS

☐ Kaylo-20 Insulating Block (data sheet)



☐ Kaylo-20 Pipe Covering (data sheet)

☐ Armstrong Armaglas** Insulations for Piping, Tanks, and Vessels



☐ Armstrong Armatemp† Insulating Cements

Armstrong Cork Company
2303 Sharpe St.
Lancaster, Penna.

Please send me the free booklets checked. ☐

Please have an Armstrong representative call. ☐

Name ....

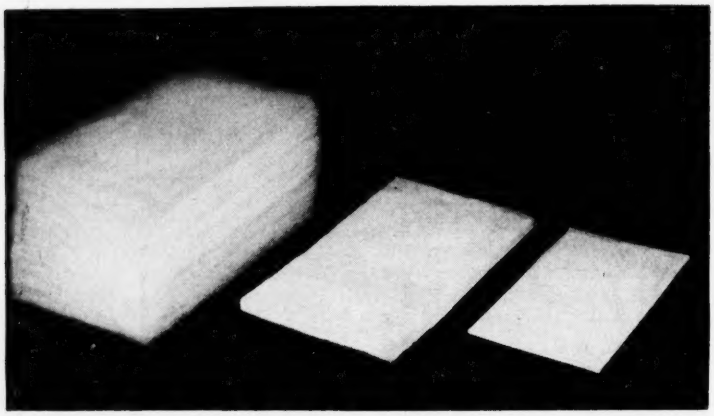
Position ....

Company ....

Address ....

City .... Zone .... State ....

** T.M. Armstrong Cork Co. Manufactured by Owens-Corning Fiberglas Corp.
† Trade-Mark



LOOSE pre-stretched synthetic fibers are felted mechanically and shrunk.

Synthetics Spread Felt Usage

Felt-like structures of synthetic fibers are formed by a new process into the same wide range of constructions and dimensions as wool felts. They handle many new jobs.

Utility of fiber-based materials for industry has been approximately doubled with the development of Feutron felts—felt-like structures consisting 100% of synthetic fibers interlocked mechanically without any binder. They are reported to be the first truly non-woven synthetic fabrics consisting of fibers only.

Already, the manufacturer, American Felt Co., can furnish the new material in essentially the same wide range of constructions and uniformly high quality prevailing for the long-established wool-felt line. This covers widths up to 80 in. and thicknesses from 0.015 to 1.000 in. Weight varies from 2 oz. to 6 lb. per sq. yd.

▶ **Engineer With Fibers**—According to Thomas J. Gillick, Director of Engineering for the American Felt Co., availability of these new chemi-fiber felts opens up an exciting new field, Fiberlurgy. Early evaluation of the felts has aroused considerable interest in:

- Filtration, wet and dry.
- Seals for high-temperature bearings.
- Reinforcement of plastics.
- Overlays for reinforced plastics.
- Wicking for high temperature use.
- Insulation, both thermal and acoustical.
- Base fabrics for special coatings and impregnants.

Among the fibers now available in the Feutron felts are: nylon, acrylic, polyester, cellulose acetate and tri-acetate, viscose, protein and metal. With such a range to choose from, you can select a felt or felts to give you the required amounts of resistance to corrosive chemicals, biological and insect pest damage, flame, heavy abrasion and moisture absorption; thermal stability and tensile strength.

▶ **Unique Gains**—A prime example of how Feutron felt makes possible entirely new performance is shown by American Felt's new gasketing material Vistex with Teflon. Here, polyester fiber felt is impregnated with Teflon to give a highly resistant gasket that is free of undesirable lateral plastic flow. Through use of polyester felt Teflon's properties can be utilized fully.

Or still another example is the use of Feutron felt as the top or surface layer for reinforced plastic laminates. A small amount of mechanical finishing followed by a solvent wipe produces a mirror finish that is completely impervious to liquid.

▶ **Old Helps New**—Synthesis enters the story of Feutron felts from still another angle than production of synthetic fibers for the felts. For the technique used in manufacture is a synthesis of the old "needling" principle of felt-making and modern engineering practice.

Many of the characteristics of wool, hair or fur felt were very desirable to reproduce in synthetic-fiber felts. Unfortunately, felting achieved with these natural fibers could not be reproduced by similar means using synthetic fibers.

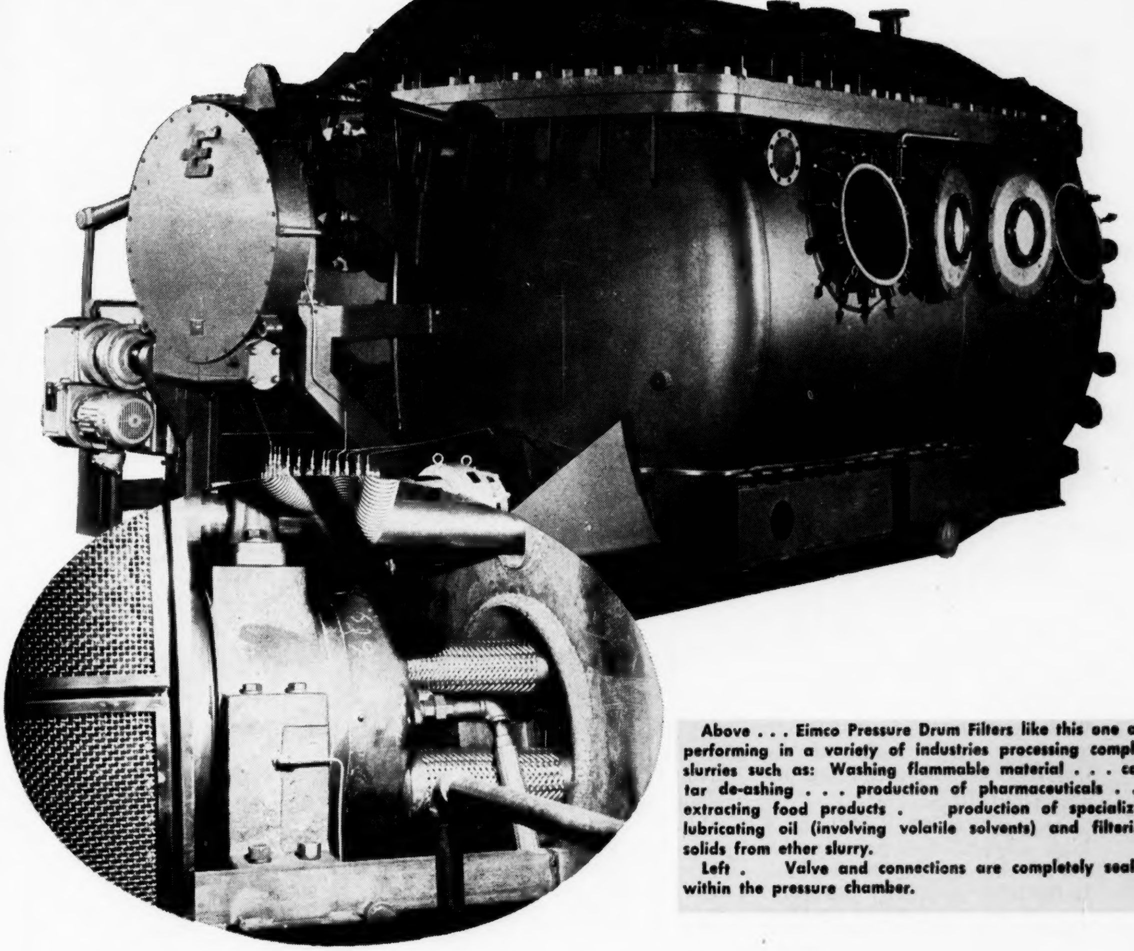
Chemi-fibers do not react in similar fashion. But with the needling process a similar end result can be achieved. Barbed needles enter the properly prepared fiber bat and retract to pull and interlock the fibers. Mechanical pressure during "fulling" controls density of the felt-like structure.

▶ **Three Types** — Three basic types of synthetic-fiber Feutron felts now are produced commercially by this technique:

- Mechanically interlocked felt with a woven-fabric foundation.
- Mechanically interlocked felt without any weave.
- Felt with fibers interlocked both by mechanical means and by shrinkage of the fibers.

This third type, which involves shrinkage of the fibers, actually approximates "true" felt (wool) closer than the other types of synthetic-fiber felt. Shrinkage of the fibers results from chemical treatment of the needled felt.

Much effort is being directed toward further development of the process for the third type. Even now, with mechanical hardening followed by chemical felting, some of these synthetic constructions can be shrunk up to 50%, which approaches the maximum shrinkage in felting of wool. — **American Felt Co., Glenville, Conn.** 196A



Above . . . Eimco Pressure Drum Filters like this one are performing in a variety of industries processing complex slurries such as: Washing flammable material . . . coal tar de-ashing . . . production of pharmaceuticals . . extracting food products . . . production of specialized lubricating oil (involving volatile solvents) and filtering solids from ether slurry.

Left . . . Valve and connections are completely sealed within the pressure chamber.

Here Are 5 Major Process Conditions...

where correct application of Eimco Pressure Filters will get you appreciable advantages:

(1) Where vapor pressure of the liquid at the filter feed temperature is too high to permit the efficient use of vacuum . . . **(2)** Where liquid viscosity is high (generally 100 centipoises or more) or solid particle size is very small, requiring a driving force greater than one atmosphere to get economic filtration rates . . **(3)** Where large labor savings and lower operating costs justify higher initial expenses . . . **(4)** Where employment of a valuable or high temperature gas for the production of a dried cake product is feasible . . . **(5)** Where filtration of saturated solutions results in excessive crystallization with a reduction in temperature or pressure.

Whether you are pre-planning for filter installations to handle new processes or are seeking to improve present operations . . . these are some of the general conditions that justify an investigation into **Eimco Continuous Pressure Filter Equipment.**

Submit your problem to the Eimco Research and Development Center, Palatine, Illinois. They have complete facilities to test your slurry on all types of filtration equipment to assist you in selection of a proper unit.

After exhaustive tests, if research shows that pressure filtration can be correctly applied to your problem, you will find that Eimco Pressure Filters offer you production (and profit) advantages.

Whatever your filtration problem, let Eimco's competent research facilities go to work for you. Write today!

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH

Research and Development Division, Palatine, Illinois • Process Engineers Inc. Division, San Mateo, California
Export Offices: Eimco Building, 51-52 South Street, New York 5, N. Y.
BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

EIMCO

B-237

Metallizing Powder

For rebuilding crankshafts, reduces friction.

A new metallizing powder has been developed specifically for rebuilding engine and compressor crankshafts. Resulting surface develops anti-friction qualities which enhance delivered horsepower and improve crankshaft life.

New Colmonoy C-250 is a high chromium-nickel powder containing chromium borides. It features unusually low coefficient of friction, controlled surface porosity and good oil retention properties. Both of these characteristics contribute to improved wear resistance and service life.—**Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich. 198A**

Vertical Pump Motors

Corrosion-proof for installation inside or outside.

Now available for all vertical pump installations is a complete line of totally protected, vertical, solid-shaft, P-base electric motors.

These motors can be supplied in choice of protected, totally enclosed or explosive-proof enclosures with normal thrust bearings, 1-40 hp., and high thrust, 1-15 hp.

Designed for installation either inside or outside, P-base motors are corrosion-proof against adverse conditions commonly found in process applications. Shaft is sealed by a neoprene slinger that protects bearings and windings. Face of the mounting flange and the rabbet fits are machined after assembly to assure perfect mating with the pump flange and to provide positive shaft alignment for quiet, long-life operation.—**Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio. 198B**

High-Voltage Starter

Compact, self - contained and accessible.

New Type ZHA high-voltage starter is self-contained, complete with control transformer to supply low voltage for push-button circuits.

Starters may be mounted directly against wall, or in double rows back-to-back, since they are completely accessible from the front. So compact is the starter that only 30 in. of depth are needed.

Interrupting ratings are available for squirrel cage, synchronous and wound-rotor motors.—**Electric Controller & Mfg. Co., Div. of Square D Co., Cleveland 28, Ohio. 198C**

Spark-Proofing Kit

For electrical systems of industrial trucks.

A new electrical spark-proofing kit now is available for the full Lamson line of standup and sitdown industrial trucks. It shields the electrical systems on the gasoline engines to eliminate the possibility of any electrical sparks being exposed to inflammable fumes.

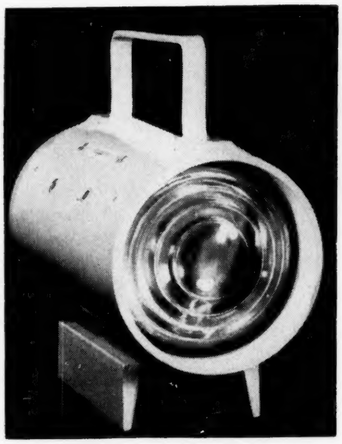
Kit, which is only installed in the factory, consists of a totally enclosed and shielded distributor, a shielded ignition coil and sealed Romax cables which enclose all high-voltage ignition wires. The standard generator is fitted with protective shields over the air vents to prevent foreign material from entering the generator.—**Lamson Mobilift Corp., Syracuse 1, N. Y. 198D**

Metal Cutting

Suitable for fabricating non-ferrous metals.

Aircomatic inert-gas welding process now can be used to cut non-ferrous metals using standard welding equipment. No special techniques are needed by the operator.

Aircomatic welding employs a consumable wire electrode arc in an atmosphere of inert gas. A wide variety of metals have been cut with quality satisfactory for subsequent welding operations.—**Air Reduction Co., Inc., 150 East 42nd St., New York 17, N. Y. 198E**

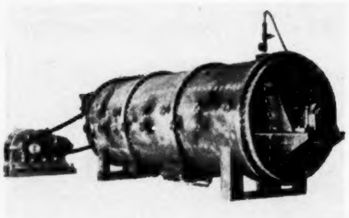


Marker Signal

Illuminated by excitation from radioactive gas.

The first commercial high-brightness safety signals and markers to utilize long-lived radioactive Krypton^{85} gas became available recently. Designed especially for installations where power and maintenance are limited, these devices come in a variety of shapes, sizes and brightnesses.

Markers employ treated phosphor crystals which are excited to luminescence by Kr^{85}. Readily visible at distances greater than 500 yd., these devices require no maintenance from the first day of installation. And cost associated with installation of circuits is eliminated completely.—**U. S. Radium Corp., Morristown, N. J. 198F**



Heavy Duty Dryer

For big, tough, hard-to-handle jobs.

Both batch and continuous dryers are available to handle drying jobs where the solids become almost an unmovable mass, yet must be mixed during the operation.

One job being handled by the pan-type batch dryer removes valuable solvent from a sludge which goes through a very high consistency range approaching that of concrete. A specially designed close-fitting agitator driven at 10 rpm. by a 60-hp. motor keeps the sludge moving. Dried solids are discharged through a side outlet.

Heat is supplied by Thermocoil cast in the wall of the cast-iron vessel.

A continuous model for the same service is mounted horizontally. Power input is lower per volume processed than with the batch unit. Both are available in fabricated steel, clad steel and alloys, in addition to the cast iron mentioned above. **—Bethlehem Foundry & Machine Co., Bethlehem, Pa.** 200A

Sublimation System

Purifies solids in a continuous closed system.

Certain solids, which can be purified by entrainer sublimation, are the type of material processed in the Wyssmont closed-circuit subliming system. Included in the system are the Turbo-Dryer sublimer, feed hopper, recirculating fans, condensers and reheater.

In the sublimer is a tier of tray shelves and turbo fans rotating on the same vertical axis within a cylindrical insulated housing. Entrainer gas flowing over material on each tray picks up subliming material and passes first to a filter, then into a series of sublimate condensers.

In the condensers, rotary scrapers remove condensed sublimate from the walls so that heat transfer rate is maintained. Freed of sublimate, the entrainer gas circulates to a preheater and back to the sublimer.

Turbo-Sublimers are built as completely shop-assembled units in sizes from 60 to 360 sq. ft. net tray area. Larger units to 18,000 sq. ft. are sub-assembled for field erection—**Wyssmont Co., Inc., 2700E Bridge Plaza South, Long Island City 1, N. Y.** 200B

Kiln Chains

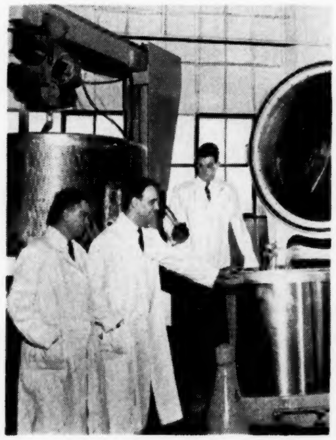
For wet process kilns, resist heat, wear, corrosion.

Newly designed links and shackles in the Thermopruf kiln chain system are said to provide longer wearing qualities, greater corrosion and heat resistance than any steel-type kiln chain. A comparatively small inventory of Thermopruf links, connectors and shackles enables you to make any length of chain required without cutting or welding.

Links are joined by inserting one leg of an open Thermopruf link through the loop of closed legs in the preceding link. Legs are closed in an ordinary bench vise.

Shackle is heart shaped with two valleys, one for each end link. This double arrangement keeps end links from riding each other and greatly reduces wear both on end links and shackles.

End connecting link is pear shaped and tapered. Cross sectional areas are greater at the points of heaviest wear. Tapered shape permits connecting directly to a Thermopruf link, eliminating stepdown links.—**Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.** 200C



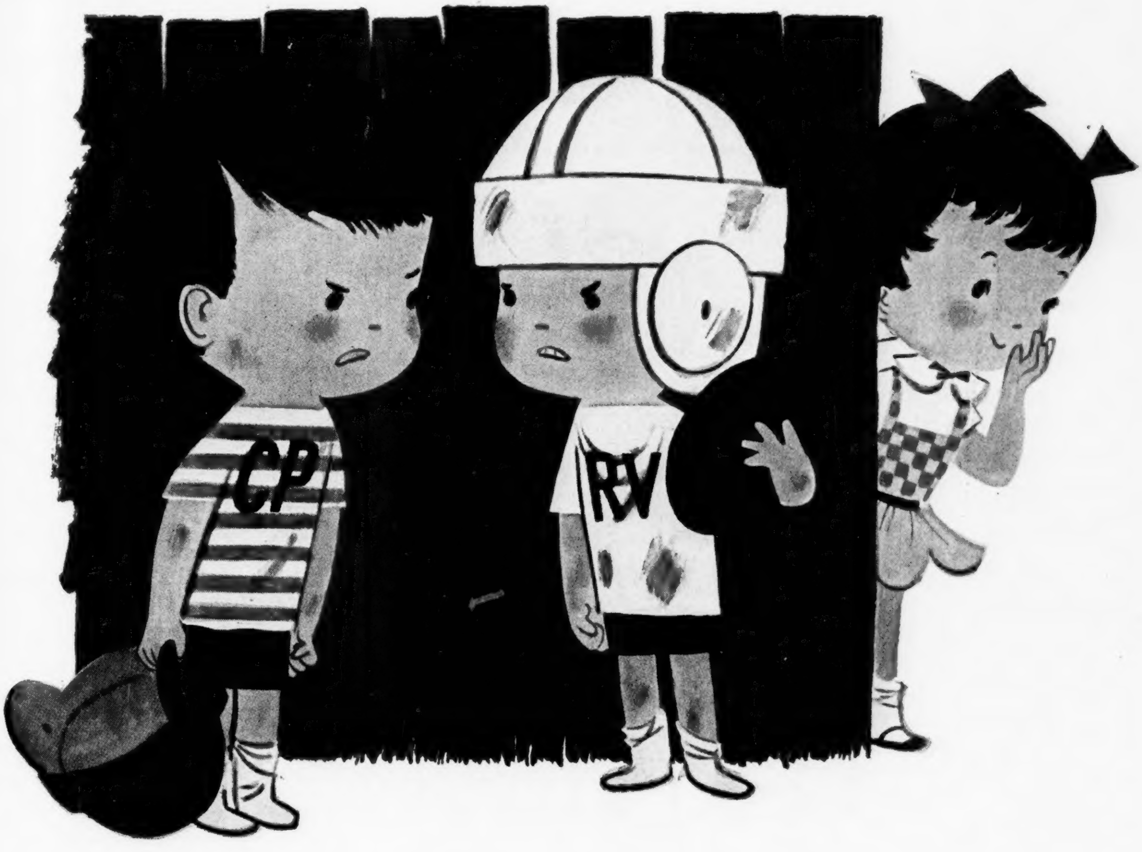
Centrifugal Showroom

Retail style for complete industrial line.

Adjacent to the testing laboratory and overlooking the firm's huge machine shop, Fletcher Works recently unveiled its retail-type centrifugal-machine showroom. In this 1,200-sq.-ft. space, prospective customers may operate the centrifugal machinery themselves.

On the showroom floor are a 48-in. Flow-Clean stainless-steel washer-extractor used by the dry-cleaning industry, large institutions and hotels; 40- and 48-in. Whirlwind extractors used by textile, dry cleaning and laundry industries; Twintainer stainless-steel 50-, 54- and 60-in. automatic extractors fitted with overhead jib boom and electric hoist for switching baskets in dye houses, laundries and institutions; models of Junior and Standard extracors used by textile, chemical, laundry and dry cleaning industries; and the chip wringer that de-oils chips and turnings. **—Fletcher Works, 2nd & Glenwood Ave., Philadelphia, Pa.** 200D

USCOLITE PLASTIC PIPE



INITIALS MEAN A LOT...in Plastic Pipe, too

That's why Uscolite® plastic pipe and fittings come in two specific types, each equally good for its particular purpose. Just pick the right initials:

Uscolite CP: a styrene-acrylonitrile-butadiene copolymer is the ideal selection where maximum resistance to impact is demanded; will handle safely most chemicals of industrial importance at working temperatures elevated to 170°F.

Uscolite RV: an unplasticized, unmodified polyvinyl chloride (PVC) is the best choice for extremely active oxidizing agents such as strong sulphuric, nitric and chromic acids. Impact strength and temperature limits are more than adequate for normal service.

Both Uscolite RV and Uscolite CP have been carefully engineered to solve particular corrosion problems. Our technical men will help you select which is better for the service conditions involved.

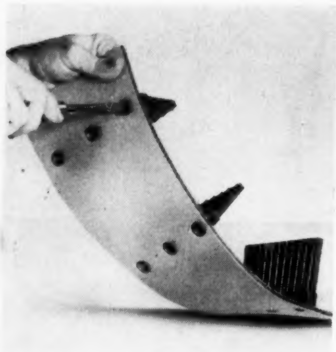
Both types of Uscolite are extraordinarily resistant to corrosion. They are non-contaminating, odorless, impart neither taste nor discoloration. Uscolite's numerous applications throughout industry continue to multiply.

If you have any problem in plastic pipe, consult any of our 28 District Sales Offices, each staffed with factory-trained engineers, or call any of our selected distributors, or write us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co. Ltd.

Look for the name Uscolite—and the right initials. They assure you of the best plastic pipe and fittings for your specific job.

Mechanical Goods Division

United States Rubber



Conveyor Belt Cleats

Screw onto any belt quickly and easily.

A recently developed molded-neoprene, screw-on cleat can convert any conveyor or elevator belt into a cleated belt. It's a simple operation done with nothing more than a punch and a screw driver.

Cleats are attached to the belt by flat-head machine screws and special countersunk washers which are secured to threaded metal inserts vulcanized in the base of the cleat.

Inserts are imbedded in concave cups. When screw is tightened against washer, it pulls belt into cup. Both screw-head and washer sink below surface of belt, where they cannot contact pulley.

Cleats are available from stock in heights from $\frac{5}{8}$ to 3 in. and widths from $1\frac{1}{2}$ to 24 in.—**T. H. Hinchcliffe, 1450 La Loma Rd., Pasadena 2, Calif.** 202A

Tank Liner Sheet

Compensates for thermal dimension changes.

A tank liner sheet developed recently has built-in corrugations to absorb expansion and contractions of installed rigid tank liners.

Individual sheets, 30 x 60 x $\frac{3}{16}$ in., of Boltaron 6200 unplasticized polyvinyl chloride can be used to line tanks of almost unlimited size since expansion and contraction are confined to the individual sheets. Problems of buckling, warping and other distortions encountered with other linings are eliminated.

Boltaron expansion sheet can be used with tanks of wood, concrete, metal in most any condition.—**H. N. Hartwell, Industrial Plastics Div., Park Sq. Bldg., Boston 16, Mass.** 202B

Self-Powered Feeder

Operates by force of falling material.

Dry, free-flowing materials are fed at rates from 200 to 2,000 lb./min. with the new Merchen self-powered feeder.

Self-powered feeder operates on the principle of balanced weights. Force produced by feed material falling onto an impact pan is balanced by a preset counterweight. Position at which the counterweight is set determines the size of the feed-gate opening above the pan.

Material striking the pan tends to overbalance the counterweight closing the gate. As force on the pan decreases, the counterweight opens the gate. These opposing forces actually balance at any desired feed rate set on the counterweight beam.

Units are available with automatic shutoff to permit starting or stopping the feeder, or synchronizing with other plant equipment. — **Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.** 202C

Industrial Tractor

Powered by motor-generator drive unit.

Following the lead of railroad locomotives, Model GLT four-wheel tractor uses a high-torque drive that has been well proven on the rails.

Power train consists of a high-output generator direct-coupled to a gasoline engine. The generator powers a high-torque electric motor which, in turn, is direct-coupled to the differential pinion.

Inherently high efficiency of this drive is said to reduce fuel consumption more than 25%. Furthermore, elimination of clutches, torque converters and mechanical or fluid transmission drastically reduces the cost of maintenance and service parts. With no mechanical connection between the wheels and the engine, road shock is not transmitted to the engine so that engine life is longer.—**Automatic Transportation Co., Div. of Yale & Towne Mfg. Co., Chicago 20, Ill.** 202D

Floating Warehouse

To operate between Trenton and Jacksonville.

Increasing quantities of soap products, shortening, lubricating oils and paint are going to travel along the Eastcoast inland waterway. For C. G. Willis, Inc., Paulsboro, N. J. has recently added to its fleet a 256-ft. barge capable of carrying 2,900 short tons of cargo. An identical companion will be delivered next summer.

Covering the cargo compartment are weathertight rolling hatch covers of welded steel. These covers telescope to allow a single opening almost half the barge's hopper length. Or they can be arranged to permit several smaller openings. Several 4-ft. square openings in the cargo compartment coaming allow for transfer of freight at way points along the waterway route.—**Dravo Corp., Neville Island, Pittsburgh 25, Pa.** 202E

Fork Extensions

For broad line of pallet-type electric trucks.

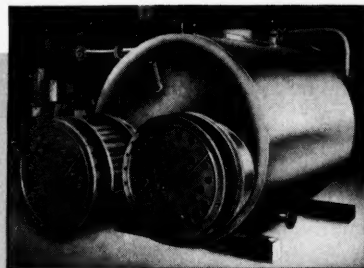
Special fork extensions have been developed for increasing the versatility of a line of electric trucks.

Attachments slip easily on to the standard forks doubling their length. With the extensions, pallet trucks are able to handle long, light bulky loads on either skid platforms or open-face pallets.

Initially designed for one customer, these attachments now are available in a wide range of sizes and are adaptable to any pallet-type truck. — **Lewis-Shepard Products, Inc., Dept. R-39, 125 Walnut St., Watertown, Mass.** 202F

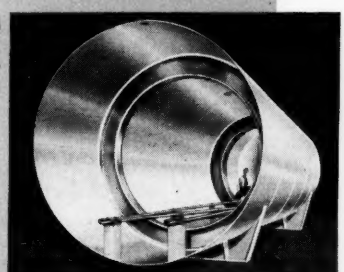
VERSATILITY

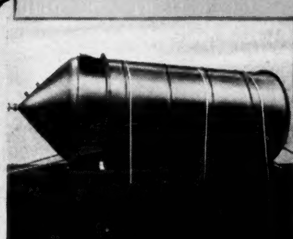
√ DESIGN
√ ENGINEERING
√ FABRICATION



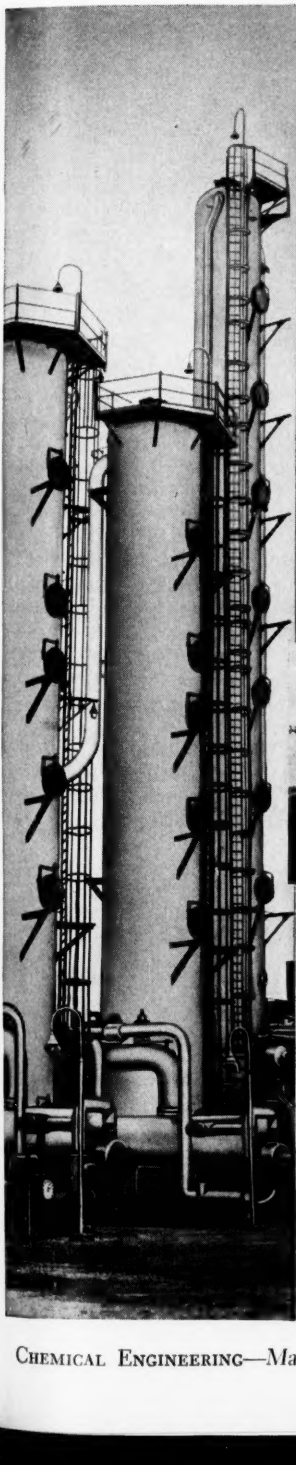
COPPER
Reboiler, with 2 Removable Bundles

ALUMINUM
Storage Tank, 12'-0" Diameter by 50'-0" Long





MONEL
Tar Base Extraction Tank, 10'-0" Diameter 25'-7" High



STEEL
Distillation Columns

STAINLESS STEEL
Double Hummer Screen, Special Design

The advantage of working with one versatile source of equipment has been recognized by leaders in the process industries. A high degree of flexibility can more effectively correlate new equipment with existing facilities.
The equipment illustrated here demonstrates Acme versatility, proved through past performance in all processes.

From pilot plant to full scale operation . . . from drawing board to actual installation, Acme is pre-eminently equipped to serve the diverse needs of the process industries.

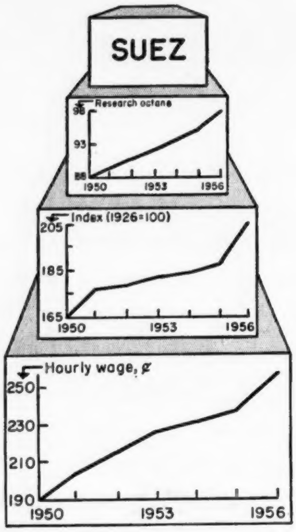
ACME
Processing Equipment
ACME COPPERSMITHING & MACHINE CO., ORELAND, PA.
DESIGN AND FABRICATION IN ALL FERROUS AND NON-FERROUS METALS.

DEVELOPMENTS . . .

CHEMICAL ECONOMICS

EDITED BY D. R. CANNON

Oil's Economic Pressures Pyramid



Octane Rating Requirements Up

Equipment Costs Up

Labor Costs Up

Now, Oil's Prices Inch Up, Too

Only one more squeeze was needed to force lid off prices. Suez cutoff did the squeezing.

It's costing more and more to find, produce, refine and market petroleum products. Add on an international supply-squeezing crisis like the Suez mess and you've got a pressure-pileup on prices which demands a safety valve.

First whistling of pressure relief came last month when Humble Oil, nation's biggest buyer and seller of crude oil, upped, by 35-45¢/bbl., prices it will pay. Right on top of this came a 1¢/gal. boost in gasoline tankwagon prices by Humble, Gulf and Continental Oil and the rush was on.

Within a week nearly all major companies were offering 20-45¢/bbl. extra for crude and charging roughly ½-1¢/gal. more for all refined products.

▶ **Last Straw**—In a word, the whole thing figures. Few were surprised, or very sorry for that matter. Oil production men, in particular, have long warned about increasing costs being largely unrelieved by price increases. Suez, and the torrential demand for crude oil to keep Europe's economy from atrophying, was the last straw and the industry knew it. It was just a question of who would make the first move.

Will the new prices stick? Most producers think continued domestic demand alone will enable them to retain better part of crude increase. Resumption of Suez traffic, though, could renew heavy stockpiling of crude, a real danger before Middle East tieup. Fuel oil markets will probably accept permanently higher prices, too.

Bloated gasoline stocks are another matter. History-making high levels make for a soft market and reluctance to ask for price hikes.

But refiners, faced with rising costs and, now, a higher priced crude, may have no alternative but to insist on at least part of present increases when Suez Canal is reopened.

▶ **Out of Balance**—A combination of higher-costing materials, equipment and payroll, plus quality improvement pervades the oil industry. In past three years truck prices have risen 10%; metal and metal products, 11%; average wages and related costs, 20%.

Capital spending plans for 1957 of more than $6 billion are 50% more than they were four years ago and double those six years ago. Refiners, alone, will spend 50% more this year than they did last year.

Contrast this with returns. For the period Aug. 1953 to Aug. 1956 the government index of wholesale prices shows industrial products up 6.5% whereas wholesale prices of heating oil are up only 5% and gas prices, excluding taxes, up only one-half percent.

▶ **Headaches Remain** — Price hikes have temporarily relieved one of oil's biggest economic problems for 1957, price cost squeeze. But at least two big ones remain:

- First dilemma is the huge gasoline inventory, up 12% in 1956 and untouched by Suez demands. Says L. F. McCollum, president of Continental Oil Co., "This problem is particularly distressing because it is one that could have been easily avoided through more prudent management of refinery operating schedules." McCollum claims a reduction of 109,000 bbl./day in refinery runs for seven months, coupled with reduction in gasoline yields of from 49.7 to 49.4%, would have held inventories to manageable levels. Upping distillate yields from 22.4%

Here's Why CHEMICAL MEN specify...

EC&M OIL-BREAK STARTERS

(2200-4800 VOLTS)

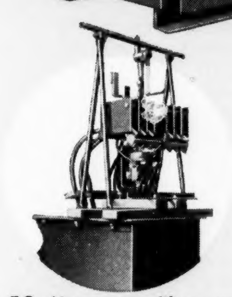
—THEY'RE *Specifically Designed* FOR DUSTY, CORROSIVE ATMOSPHERES

Exterior and interior views of EC&M Type ZHS High Voltage Starter in NEMA 3R (raintight) enclosure with threaded connections for conduit

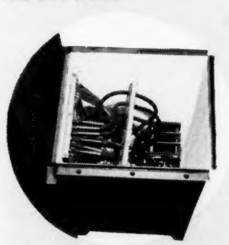
EC&M Type ZHS Starters are a "natural" for chemical plant service because the high interrupting capacity ZHS contactor operates under oil. Being totally oil-immersed, this contactor is always well lubricated, protected from corrosion and requires infrequent inspection. There are additional advantages—

QUICKLY INSTALLED because starters are shipped with all internal wiring complete. These ready-to-use starters cut installation time and cost.

HIGH INTERRUPTING CAPACITY • These EC&M Starters are available in enclosures for indoor or outdoor mounting, and are supplied in 3 ratings—*(1)* 50,000 KVA (certified) interrupting capacity (inherent in the starter)—*(2)* with power-type, current-limiting fuses—*(3)* VALIMITOR® (volt-ampere-limitor), the bus may be of unlimited KVA.



With EC&M contactor-lifter, contactor is easily raised above oil level for easy inspection without disconnecting any bolts or leads



Down-view into oil tank. Note compactness of contactor and transformer assembly. All leads are anti-syphon

An installation of two EC&M 2300 volt, reversing dynamic braking starters in a large rubber plant

For the complete story, write for Bulletin 8130-CH

THE ELECTRIC CONTROLLER & MFG. CO.

A DIVISION OF THE SQUARE D COMPANY

CLEVELAND 28 • OHIO

8170

Domestic Petroleum Demand: Records Behind, Records Ahead*

(1,000 bbl./day)

	1956	% Increase Over 1955	1957	% Increase Over 1956
Gasoline	3,804	5.0	3,967	4.3
Distillate fuels	1,734	8.9	1,803	3.9
Residual fuels	1,555	1.8	1,575	1.3
Liquefied petroleum gas	443	13.3	482	8.7
Lubricants	121	3.8	122	0.8
Jet fuel	186	20.8	218	17.0
Asphalt	242	4.5	271	11.7
Kerosene	331	3.3	325	−1.7
All oil	8,899	5.8	9,265	4.1

* Atlantic Refining Co.

to 22.7% would have taken up distillate slack.

• Second problem concerns most efficacious movement of crude oil to Europe until Suez Canal reopens. The Government has already given its blessing to coordinated action by oil companies to do the job. Continental's McCollum warns against the too-simple expedient of increasing domestic oil production (with the necessity of turning it off again when crisis abates) before further withdrawals are made against sizable crude oil stocks on hand in this country, particularly in inland regions where surpluses exceed those in coastal areas.

▶ **Outlook Good**—Problems notwithstanding, oil's general outlook for 1957 is most assuredly healthy for all petroleum products :

Gasoline—domestic sales up 4% in 1957. Increase of 3-4% in gasoline-consuming vehicles on roads will do it. Military switch to jet fuel will cause avgas demand to level off.

Distillates—only 4% gain for Diesel fuel. Railroad conversion almost complete. Most gains will be due to new trucks and buses. Heating oils will climb 5-6%, a little less than expected 7% increase in home burners because newer units are more efficient, newer houses better insulated.

Residual Fuel—little change. Added supplies of this industrial oil not available anyway. Refiners make less and less of this residual material.

Jet Fuel—up 12% because of military demand. But jet fuel still meets less than 3% of total oil demand.

Asphalt—demand up 11.7% as Federal highway program gets under way.

LPG—demand up 8.7%. Chemical industry requirements and motor fuel needs will be the biggest factors.

Lubricants—only a modest increase. Ratio of motor oil use to gasoline use continues to decrease. Further advances in efficient lube use expected.

Crude Oil—domestic demand of 9,300,000 bbl./day, up 4.1%. Run to stills to be 8,221,000 bbl./day, up 3.2%.

Well Completions—58,850. Although this is 2,184 more than 1955 record, roughly three-fourths were either service wells or dry holes. Thus, number of new productive wells may show first dip in six years.

▶ **Watch Washington** — Oil men will be watching the new Congress as it gets down to work in Washington.

Requests to restrict imports of crude oil will be deferred until European needs, occasioned by Suez crisis, abate. Then look for new proposals.

New certificates of necessity—with accompanying fast tax writeoffs—will probably not be forthcoming for capital projects in view of government's willingness to grant tax relief for only that capacity which is clearly necessary to national security.

Depletion allowances will stay at present level. Oil industry, figuring best defense is good offense, is pleading for increased allowances.

Resources development will get more government help in view of Middle East developments. Oil shale work and synthetic gasoline projects will benefit.

Natural gas controls will be reappraised. With White House help Federal controls on gas production should be relaxed somewhat.

▶ **Octane Orgy**—Refiners have a tiger by the tail: super octanes. They're at the level where each number added draws blood.

Octanes have been climbing for some time, with some pretty big jumps for individual years. But a lot of the increases reflected natural reactions to two war-interruptions in operations to gratify consumer needs.

After World War II and after Korea there was a drive to make up for lost time. Gas quality improved. Also, industry used equipment installed for avgas manufacture more efficiently than was feasible in wartime. Result: A better motor fuel.

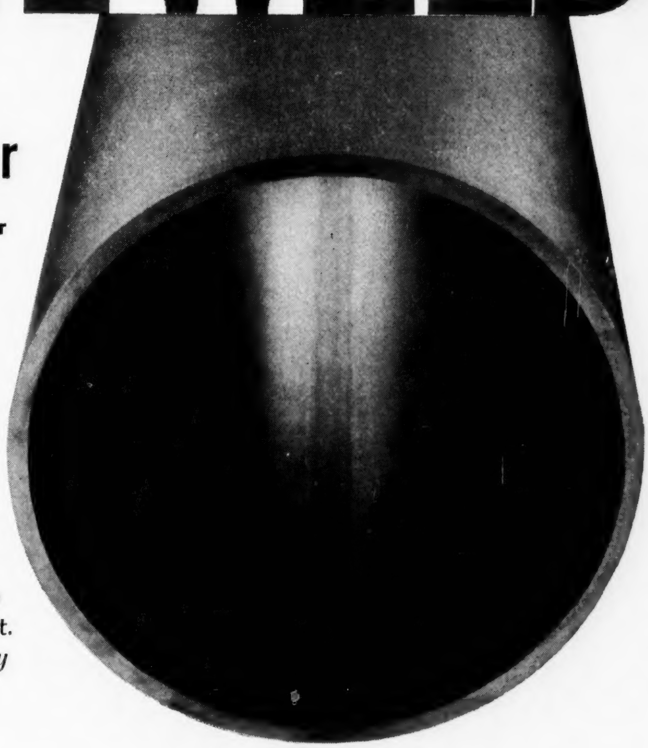
Octanes would have leveled then but for the competitive exigencies of the race to feed the souped-up cars coming out of Detroit.

At 97-98 (Research octane rating) the limit of normal refinery operations has been reached. Special catalytic reforming techniques like Rexforming, Platforming, Ultraforming, as well as newcomers like isomerization and hydrogen processing, are a must if octanes are to get up to and over 100.

▶ **Less Latitude** — For the refiner's flexibility is almost gone. He's approached the legal limit for tetraethyl lead addition (more wouldn't improve antiknock quality much, anyway). He's pretty much run out of regular alternate feedstocks—like distillates and residual oils—for conversion to gasoline via cat cracking and thermal reforming. Diesel engines, industrial and home fuel demands and jet planes compete too hard for these other fractions.

Thus he must either work over the gasoline fraction he has, sacrificing yield for extra octanes, or go for the fancy processes. Either route costs money.

CONTOUR-TRENTWELD



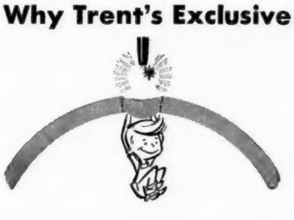
welded stainless pipe that's smoother, stronger

New Contour-Trentweld outperforms any other pipe, welded or not. Here's why: *Contour-Welding* is an entirely unique method of producing pipe and tubing. It puts gravity to work to pull down the molten weld metal until it exactly conforms to the contour of the pipe. Result: A smooth pipe or tube free of undercut or bead.

What's more, the *Contour-Weld* process *starts* with uniformly rolled stainless strip, which insures constant wall thickness throughout the pipe.

But the only way you can fully appreciate the advantages of new *Contour-Trentweld* is to try it. We think you'll agree, *it can't be beat by any other pipe, welded or not.*

Why Trent's Exclusive Contour-Welding Process Means Smoother Welds . . .



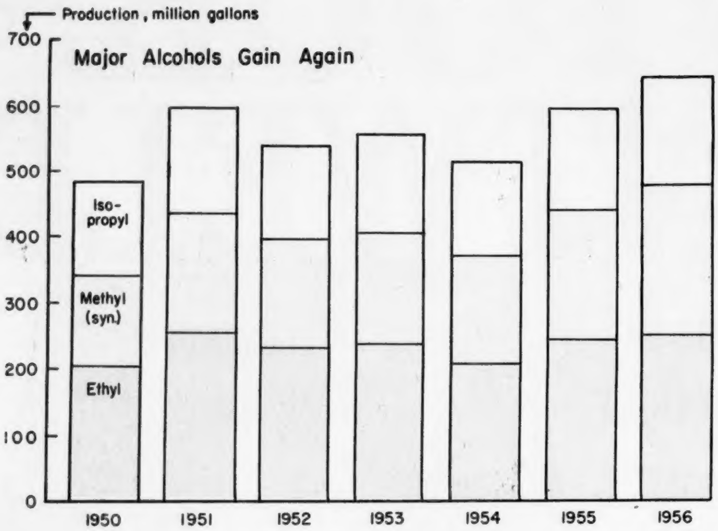
Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the I.D. surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.

But Trent put a stop to that – simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom – and gravity works for them. For then, the bulge is in the opposite direction – blending in perfectly with the contour of the pipe itself.

CONTOUR TRENTWELD

Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)



1956: Solid Gains for Solvents

Prices and demand held up so strongly last year that alcohol and solvent producers were moved to tack a tidy gain even on 1955's record output.

Putting two production-jumping years back to back—something they don't always do—solvent and alcohol makers turned out 8% more product in 1956 than in 1955, itself a record year (15% better than 1954).

A majority of solvent plants operated at full capacity last year as most producers reported 5-10% gains in their business. Threefold stimuli: Price advances of 2¢/gal. for ethyl and isopropyl alcohols, $2\frac{1}{2}$¢/gal. for methanol, and $\frac{1}{2}$¢/lb. for ketones and other solvents (esters and higher alcohols), all announced at outset of 1956; accelerated demands at beginning of year; and high level of business in general.

1957 should be another good year although gains may be more modest. Producers, near the top of their capacities, will not step up output much unless nation's economic level moves up at faster-than-expected rate this year.

▶ **Ethyl Price Lags**—Ethyl alcohol production for 1956 is estimated at 252 million gal., up about 6% over 1955. All producers entered 1956, as they did in 1955, with low inventories. Output of three large producers, National Distillers, Carbide & Carbon, and Shell, was, in fact, slightly behind their sales demands.

So firm was ethyl's price structure at the beginning of the year that pressure for additional price rises bore down upon the market throughout the year.

Here's why. First of all, ethyl alcohol was a little short. The large quantity of French alcohol was liquidated during the year. Limited amounts of molasses available at economic prices curtailed fermentation production of ethyl alcohol.

Secondly, demand was strong. Requirements for polyethylene production and other outlets forced producers to divert ethylene normally ticketed for alcohol. Ethylene to meet these non-alcohol demands was credited with higher values than those charged into alcohol. Hence the feeling by synthetic producers that ethyl's price should be raised to reflect those higher values.

All ethyl alcohol plants operated at reasonably satisfactory levels during 1956, as they did in 1955 (except for ethylene shortage previously mentioned). Estimated synthetic production was 190 million gal., compared to 178 million gal. in 1955 and an installed capacity of 215 million gal.

Synthetic alcohol accounted for 71% of total consumption; if we deduct imports of 14 million gal., consumption of synthetic moves to 77%.

▶ **Methanol Tight, Too** — Production and demand for synthetic methyl alcohol reflected over-all expanding economy. 1956 production was about 227 million gal., 10% over 1955.

Demand for formaldehyde and pentaerythritol for plastics increased considerably so that methanol, very tight at 1955's end, got a $2\frac{1}{2}$¢/gal. price hike at 1956's outset.

Market is still so firm that Du Pont, Commercial Solvents and Olin-Mathieson announced capacity expansions. By 1958 methanol production will be up nearly 50 million gal.

As usual, wood distillation alcohol was sold as a denaturant for ethyl alcohol. Latter's high demand carried wood alcohol sales to very satisfactory levels.

▶ **Acrylics Help Isopropyl**—Production of isopropyl alcohol in 1956 was about 165 million gal., 6% above 1955. Sales were so good that the three producers, Carbide, Enjay and Shell, ended the year with no inventories and were faced with a possible shortage during 1957's first quarter. (Shell announced it would increase its capacity by 17 million gal.)

Isopropyl's use in petroleum industry gained momentum over the year. Newer acrylic-type protective coatings prefer ketone solvents to ester types; thus, acetone (big consumer of isopropyl) sold very well. Another factor firming isopropyl market was reduced acetone production via fermentation.

▶ **Higher Ketones Come In**—As already indicated, acetone demand was firm throughout 1956. Solvent closed out year with low

DU PONT ELASTOMERS in Industry

Tank linings of HYPALON® for extra-high resistance to oxidizing agents

Long-lasting protection for storage and processing tanks handling some of the *strongest* oxidizing agents is now possible, thanks to tank linings of HYPALON, Du Pont's new synthetic rubber. These are the special applications where severe service conditions justify the use of a special-purpose elastomer coating.

Applied by standard lining methods, resilient linings of HYPALON resist deterioration from such chemicals as chromic acid, sodium hypochlorite and pickling solutions. For the complete list of chemicals to which HYPALON has superior resistance, use the coupon below.

The resistance of HYPALON to chemical attack suits it well for *particularly demanding jobs* in the chemical industry. Its extra-long service life can mean savings in replacement and maintenance in each of these products:

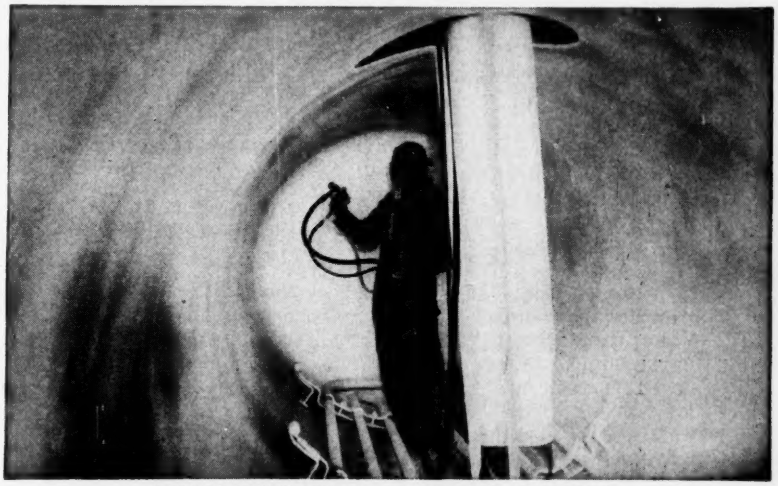
- Acid hose
- Gasket and packing
- Tank linings
- Protective coatings
- Molded parts
- Roll coverings

Other properties of HYPALON include exceptional resistance to heat, complete ozone resistance and resistance to abrasion and flex cracking.

Remember the name HYPALON when a rubber product is needed that must withstand the most severe oxidizing conditions in your laboratory or plant.

THERE IS A LONG service life ahead for this tank section used for storage of calcium hypochlorite. It's lined with HYPALON.

NEOPRENE coatings give 5 years' service in tank cars carrying hot concentrated caustic



WHITE NEOPRENE LINING is sprayed on the interiors of tank cars used to ship hot, concentrated caustic soda.

Neoprene coatings have solved the problem of transporting and maintaining the purity of rayon-grade caustic for the Columbia-Southern Chemical Company, one of the largest caustic-soda producers in the country. Used as a lining in hundreds of tank cars, these durable coatings prevent iron contamination and are giving an average of 5 years' service.

The neoprene linings successfully withstand the attack of 50% and 73% caustic soda shipped at temperatures ranging from 145° F. to 250° F. The linings can be applied in about 72 man-hours, including sandblasting, vacuum cleaning, application of two brush coats of chlorinated rubber primer and 12 to 14 spray coats of neoprene latex resulting in a coating of 20 mils.

The neoprene coatings have served so satisfactorily in tank cars that Columbia-Southern has adopted the same type lining for storage tanks and as a coating for tank-car exteriors.

This is a typical example of how neoprene can reduce maintenance costs. Its service record is also exceptional where exposure to oil, heat, chemicals or weather is a factor. For more information about neoprene used in hundreds of other products such as gaskets, hose, cable or gloves, fill out and mail the coupon below.

DU PONT

REG. U. S. PAT. OFF

☐ I am particularly interested in ____________

☐ Please send me a copy of your free publication "The Du Pont Elastomers."

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. CE-3
Wilmington 98, Delaware

Name ____________ *Position* ____________
Firm ____________
Address ____________
City ____________ *State* ____________

inventories and a firm price structure.

Market for methyl ethyl ketone was, as in 1955, extremely good. All producers were able to sell their entire output with the two larger ones, Shell and Enjay, planning an increase in facilities by latter half of this year.

Increased demand for vinyls and replacement of *n*-butyl acetate by methyl isobutyl ketone kept MIK producers hopping.

Carbide introduced some high molecular weight ketones last year which will affect solvent business in 1957.

▶ **High Alcohols, Esters Slip** — Sales of higher alcohols and esters did not keep pace with overall demand for solvents. This decline is partially due to a change in protective-coating industry where ester-type solvents continue to lose ground to ketones, and partially due to curtailed production of *n*-butyl alcohol.

Ketones have a better intrinsic value as paint solvents than their corresponding acetates. At the same time, their raw materials, the alcohols, whether from fermentation or synthesis, have higher values than are reflected in alcohol selling prices.

As in 1955, the two producers of isobutyl alcohol were often inclined to sell their product at low prices when their tanks were full.

Amyl alcohol's market was firm in 1956, but with a shift in source of supply as amyl from the three Oxo processors made substantial headway at the expense of amyl from other processes. Expect this trend to continue more strongly this year.

▶ **Levels Ahead for Alcohols** — While markets for formaldehyde- and pentaerythritol-type resins should continue to increase, methanol anti-freeze markets will continue to yield to ethylene glycol which had its biggest year ever as anti-freeze.

Economically, the growth of methanol depends on demand and value of ammonia, since they are co-products. So it is expected that methanol will show only normal growth during 1957.

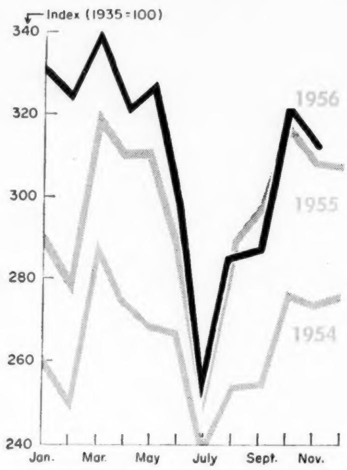
With cheap molasses virtually gone, fermentation ethanol will slip further unless producers can convince government to release surplus grain at very low prices. A government committee is currently reviewing this proposal.

▶ **Need for Raw Materials** — With increased demand for polyethylene, polypropylene, vinyl resins, styrene and elastomers, the raw materials which have been going into alcohol production are being siphoned off into the plastics field. Hence, raw material makers are not under same pressure to sell their products as they have been in past years.

Several new alcohols were announced last year, as a result of changing Oxo process techniques; it is certain more will be developed in 1957. This more economical process will tend to keep price levels down and may enable detergent manufacturers to bring out new type products. These in turn would increase markets for these higher alcohols considerably.

New production—from Stanolind's rehabilitation of large synthetic plant in Texas—did not materialize in 1956 as anticipated.

Chemical Consumption



Consumption by Industries

	Oct. (Final)	Nov. (Est.)
Coal products	12.0	11.6
Explosives	12.7	11.1
Fertilizer	69.1	69.3
Glass	26.6	26.4
Iron & steel	20.3	19.4
Leather	4.0	4.1
Paint & varnish	33.7	29.2
Petroleum refining	30.7	31.3
Plastics	25.3	26.0
Pulp & paper	39.2	37.4
Rayon	27.5	27.5
Rubber	7.3	6.3
Textiles	11.1	11.1
Total	320	311

Nation Will Gain from Tax Aid to Small Firms

Tax relief for small business —a much-discussed possibility these days—is vital in meeting nation's needs for the tools of automation and for technical manpower. So says a spokesman for small business, Robert Sheen, president of Milton Roy Co.

Sheen points out that 97% of all companies producing instruments and related products are in the small business category (less than 500 employees). Almost 95% employ fewer than 250 people, 80% fewer than 50. This same small business category (for all industries) has been the scene of an increasing number of sell-outs, mergers and consolidations in recent years, too.

Biggest roadblock for these harried firms is lack of capital to take an idea through to successful manufacture and sale. Sheen puts forth some specific proposals to help them:

- Permit any business, large or small, to depreciate its first $50,000 of capital investment in any one year in any manner it chooses. Write it off in a year's time, as an expense, if need be.
- Permit corporations, for the next five years, a credit against taxable income of $1.50 for every $1.00 contributed to educational institutions. True, the government would be a partner in paying for educational needs. But private enterprise would decide where the money would be spent—and how much.

Today, corporations are permitted 5% of net income for charitable and educational deductions. Sheen maintains that many companies, particularly the smaller ones, can't afford such a big slice of their income. Government credits would, then, help industry maximize its assistance to education.

PHILOLOGY and FILTERAIDS

Joseph Conrad speaks of words "debased by centuries of careless usage," and a glance in any good dictionary does show that many of our everyday words no longer have any clear-cut meaning. This is particularly true in the field of filtration, where many people become confused between filteraid quality and filteraid grade. This confusion is probably compounded by the diatomite industry practice of naming their different filteraids, rather than designating them by a simple direct-reading grade designation.

We might better talk of filteraid efficiency — the ability to give maximum throughput with consistent clarity at minimum dosage. This high performance is essential both for your product quality and to hold operating costs in line. There are many cases where the production rate of an entire plant depends directly upon the output of the filter station. And high performance is a function of *both* quality and grade.

In diatomite filteraids, quality and grade are not the same thing. Every major filteraid supplier has available a series of grades, ranging from a fine particle size grade to a coarse particle grade, with flowrate increasing and clarity decreasing as the particle size increases. This series permits matching the filteraid to the characteristic of the feed liquor.

However, filteraids from different suppliers may be equivalent in grade but vastly different in quality or efficiency. The poor quality material may develop flowrate equal to the better material but be inferior in clarity. Or, clarity may be achieved at the expense of flowrate. The most common weakness, however, of poorer quality filteraids is their inability to cope with the occasional tough batch of liquor encountered in almost every plant.

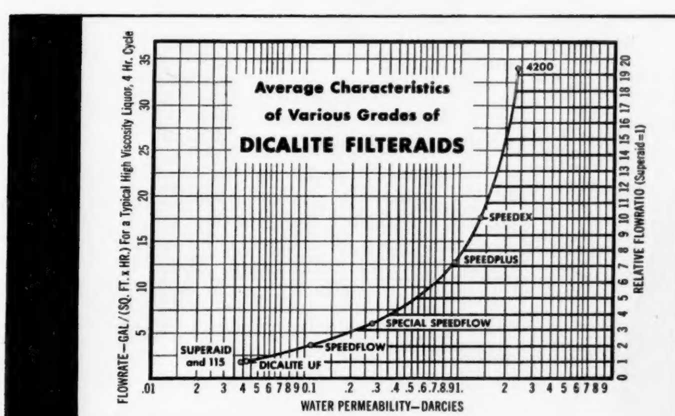
This property — the ability to handle the tough batch, at economically sound dosage — is the true test of a top quality filteraid. This characteristic is not built into a filteraid by accident. It takes sound experimental work, based on years of experience in filtration, to develop the basic information as to particle size distribution and other characteristics required in a good filteraid. And, to make this knowledge effective, quality filteraid production must be backed by control of reserves of high quality raw materials, together with milling and sizing equipment which will process the material within the very narrow limits imposed by a system of rigid quality controls. To date, this is the only known method to insure top quality in diatomite filteraids.

P. W. Leppla
Technical Director

...but just one quality!

*F*ilteraids and certain kinds of fruit have this one thing in common — that *grade* is a matter of size, and has no reference to quality. The smaller fruit may be the equal of the larger in everything but size.

Filteraid quality means the highest possible degree of clarification for the grade employed, at greatest throughput per quantity of filteraid. Dicalite achieves this high quality—in every grade—by (1) careful selection of the crude diatomite from Dicalite's four high-grade deposits; (2) processing with the industry's most modern equipment, and (3) the industry's most rigid quality control system, which assures the same carefully controlled particle size range and distribution for each grade, uniformly, dependably, lot after lot. Which may explain why so many leading firms in every branch of processing have standardized on Dicalite Filteraids.

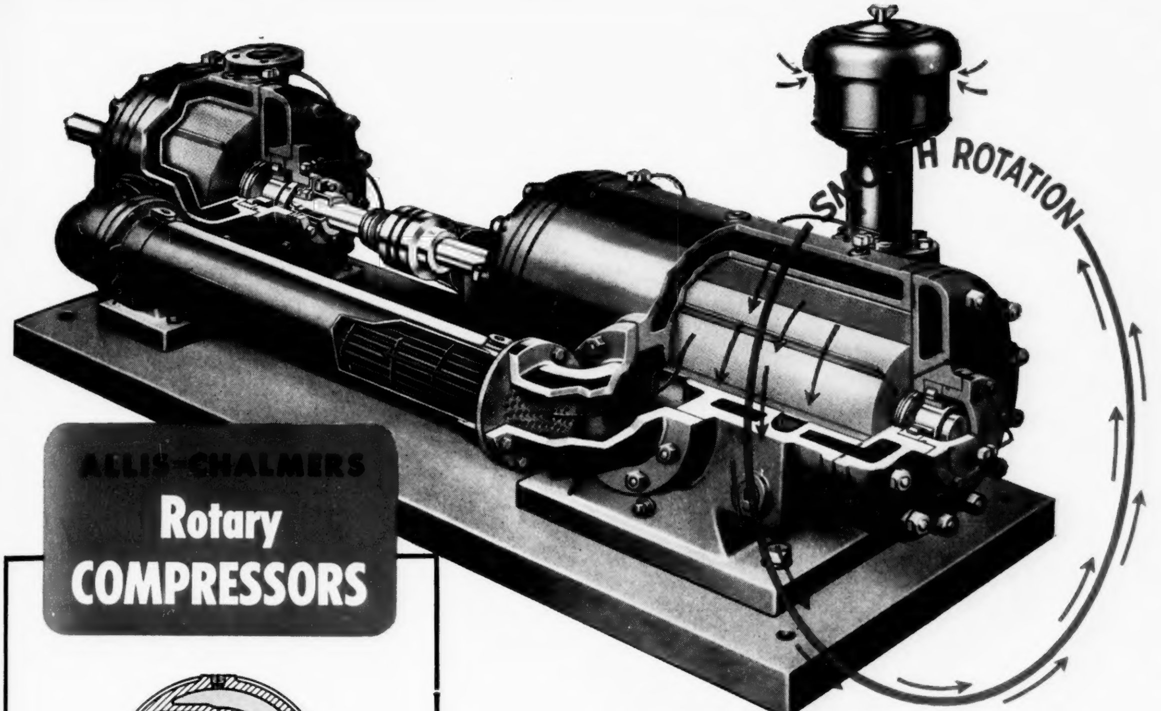


DICALITE HAS SEVEN GRADES OF FILTERAIDS ...BUT ONLY ONE QUALITY—THE FINEST!

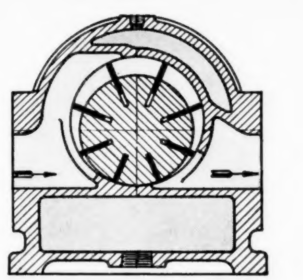
For more complete information, write

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

dicalite division, great lakes carbon corporation 612 south flower st., los angeles, california



ALLIS-CHALMERS
Rotary COMPRESSORS



How Ro-Flo units operate: Centrifugal force moves vanes to outside wall to form air chamber.

Smooth-running Ro-Flo Compressors cut vibration, and provide...

Constant Efficiency

YEAR after year there is no change in the efficiency of a *Ro-Flo* compressor.

Efficiency always remains uniformly high even if parts wear. Here's the reason:

During operation the sliding vanes of the rotor (see cross section above) press against the cylinder wall to form air cells. Even if these vanes wear, the centrifugal force holds them in contact with the cylinder wall so that the air cell never changes and efficiency and air flow remain constant.

Rotary Means Smooth Operation

Smooth rotation cuts vibration ... eliminates need for heavy foundations. Small *Ro-Flo* units can be bolted directly to the floor. Large units need only a simple slab.

Maintenance is low. There is no wear and tear on compressors from shock and vibration ... no pistons and valves.

A Type and Size for Every Need

Single-stage units for pressures to 50 pounds gauge, and volumes from 42 to 3245 cfm. Two-stage units for 250 to 1800 cfm at pressures from 60 to 125 pounds gauge.

Single and two-stage vacuum pumps for vacuums to 0.3 inch mercury absolute from 22 to 5950 cfm.

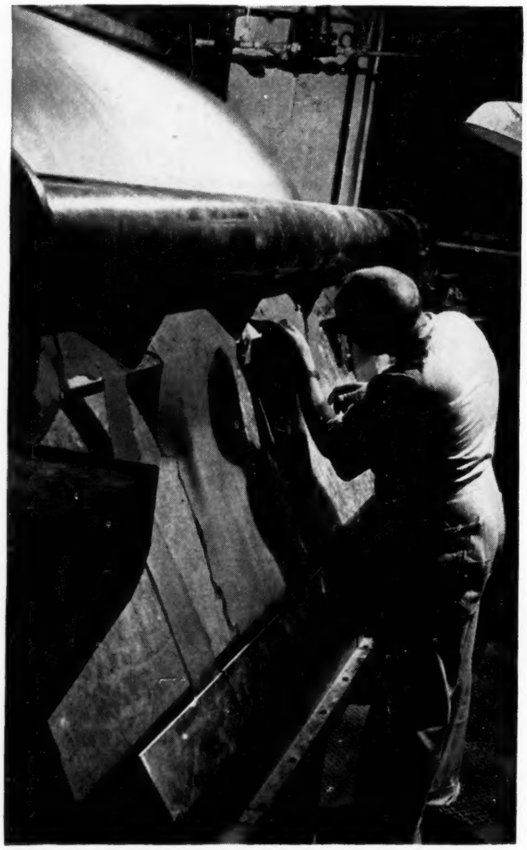
GET INFORMATION — Call your nearest A-C office or write for bulletins 16B8244 (2-stage) and 16B8126 (1-stage). Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

Ro-Flo is an Allis-Chalmers trademark.

ALLIS-CHALMERS A-C ALLIS CHALMERS

A-5134

PROCESS FLOWSHEET EDITED BY T. P. FORBATH



RAW MATERIAL for one booming antibiotic comes from process stream of another. Aureomycin (above) is the starting point for . . .

Tetracycline: Engineered to Market

Locked in hot battle for a booming market, Lederle looks to process know-how for a competitive edge.

In the case of antibiotics the traditional alliance of the miraculous and the rare has been dissolved. For, though still "miracle" drugs in their utility, antibiotics today rate as bulk chemicals supplying a steadily expanding and strikingly profitable market place.

In 1956 some 1.6 million lb. grossed, at the manufacturers' level, $300 million in medicinals alone. And R. A. Gosselin & Co. (Boston), industry market researcher, predicts that in 1957 sales will grow to 2 million lb.

Of the ever-multiplying antibiotic family, tetracycline rules as the dollar kingpin. It accounted for 40% of all antibiotic sales in 1956 with about 200,000 lb. worth some $120 million.

▶ **Three Hot Competitors**—Right now three outfits manufacture this antibiotic—each under its own brand name. Lederle Laboratories (Pearl River, N. Y.) puts out Achromycin, Chas. Pfizer & Co. (Brooklyn, N. Y.), Tetracyn and Bristol Laboratories (Schenectady, N. Y.), Polycycline.

Exactly how much each produces, however, the companies shy from reporting. Lederle acknowledgeably rates as the largest, primarily because it was the first to swing into full production (early in 1954). Bristol (who also supplies Squibb and Upjohn) and Pfizer, however, are running hot on its heels.

▶ **Two Processes**—Lederle and Pfizer travel much the same process route. Bristol strikes out on a slightly different track.

Bristol produces the tetracycline directly via fermentation, then goes on to leach it from the mash and crystallize out a pure product. Lederle and Pfizer, on the other hand, turn up chlortetracycline (Aureomycin) in their fermentation operation. Then, after leaching and crystallizing out a pure product, they catalytically dechlorinate the Aureomycin to come up with tetracycline.

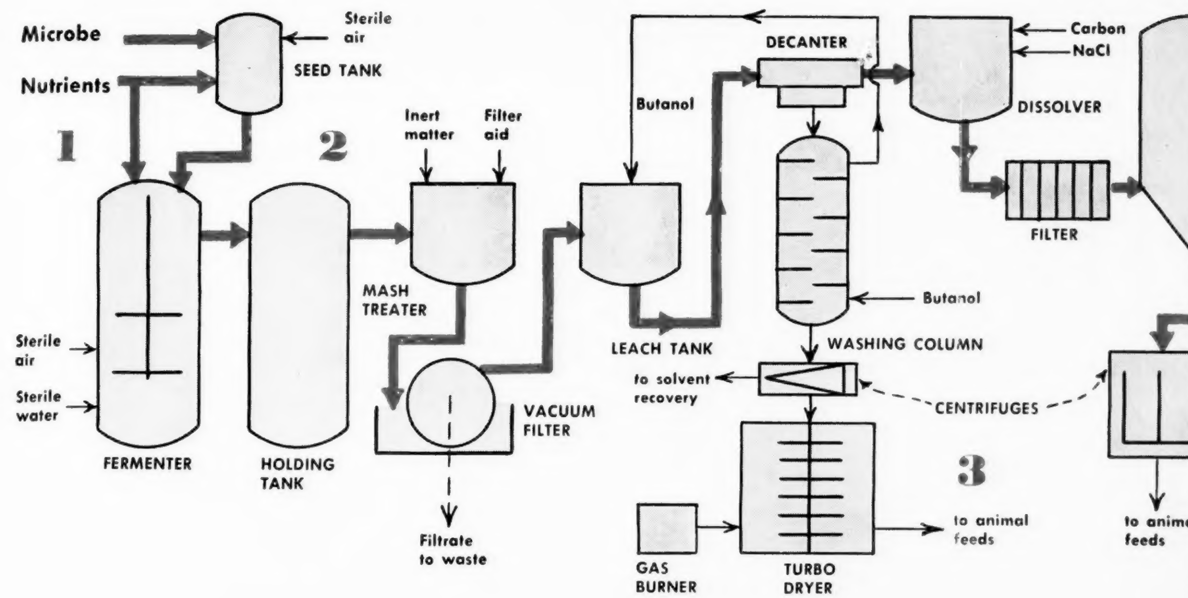
▶ **Batch Beginning**—In the spirited horse race for the market, Lederle looks to engineering know-how to maintain its competitive edge. Its prime target: Highest antibiotic recovery from starting materials at the highest production rate.

Lederle runs its fermentation on a batch basis to allow close control of optimum operating conditions, so urges antibiotic-producing *streptomyces aureofacien* to maximum production. Too, Lederle researchers are continually developing more industrious strains of the microbe and more effective nutrients for them to feed on.

Without specifically citing numbers, Lederle reports that it now gets higher production from considerably less starting materials than ever before thanks to a particularly busy microbe strain that it's recently bred. In this way Lederle has continuously boosted its plant's production potential without physically expanding the installation.

▶ **From Batch to Continuous**—Directly after the fermentation stage Lederle switches into continuous operation to get a top production rate. Twenty-thousand-gal. fermentors supply mash to four 20,000-gal. holding tanks. These tanks then continuously feed the rest of the flowsheet. Lederle schedules its fermentors as needed to keep these four tanks equipped to meet the production rate.

Continuous operation centers around the initial



leaching of the filtered fermentation mash. Slurried in solvent, it feeds to a decanter where it separates into an antibiotic-rich liquid layer and a solid mycelia layer. Solids drop through a baffled column, counter-current to solvent stream, for further washing. This solvent stream flows back to slurry the filtered fermentation mash; solids, still retaining some antibiotic activity, are dried and marketed as animal-feed supplements.

Liquid layer goes to a vacuum concentrator where crude crystals are dropped out. Then they are redissolved and recrystallized to get a pure product.

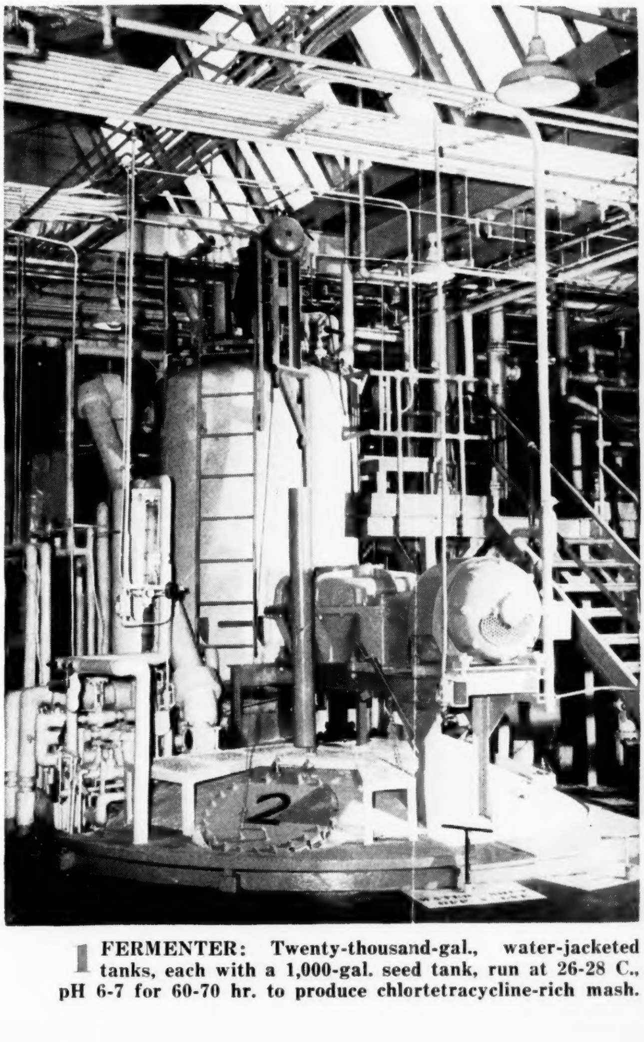
Degree of antibiotic recovery in the leach and crystallization steps, Lederle feels, depends largely on the type of solvents used. To leach the mash it uses butanol; it recrystallizes pure product from ethylene glycol monoethyl ether.

► **Catalytic Hydrogenation**—To convert the chlortetracycline to tetracycline, Lederle runs a catalytic reduction in a hydrogen atmosphere. Though Lederle refrains from specifying the catalyst it's using, the literature reports palladium-on-carbon as the most successful for this operation.

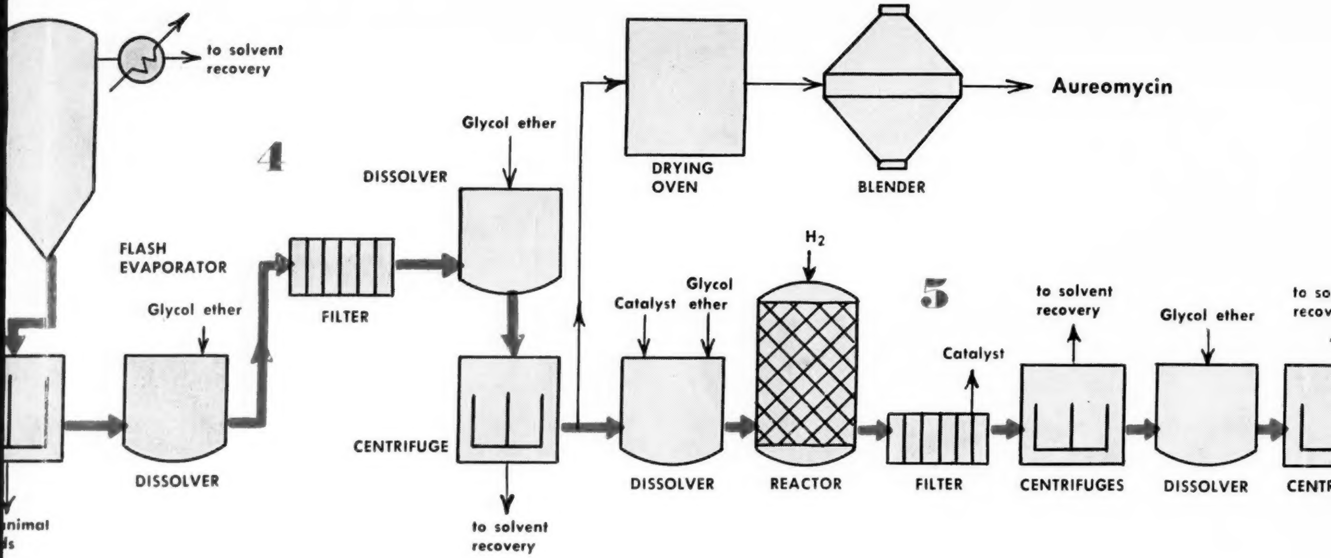
Pure crystals of Aureomycin are slurried in the glycol ether with catalyst pellets and introduced to a reactor. After the dechlorination and hydrogenation the pure tetracycline is crystallized, dried and blended for market. Lederle also sets aside a portion of its chlortetracycline production to be sold as Aureomycin.

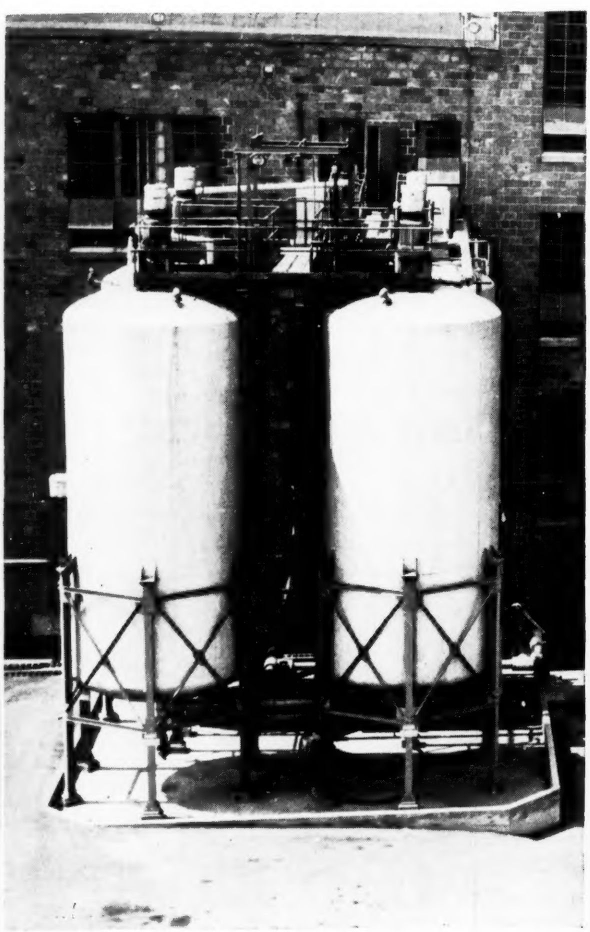
► **Beating Corrosion**—As in most fermentation-based operations, contamination from corrosion poses a serious threat to product purity and recovery. So Lederle is always searching for more effective materials of construction.

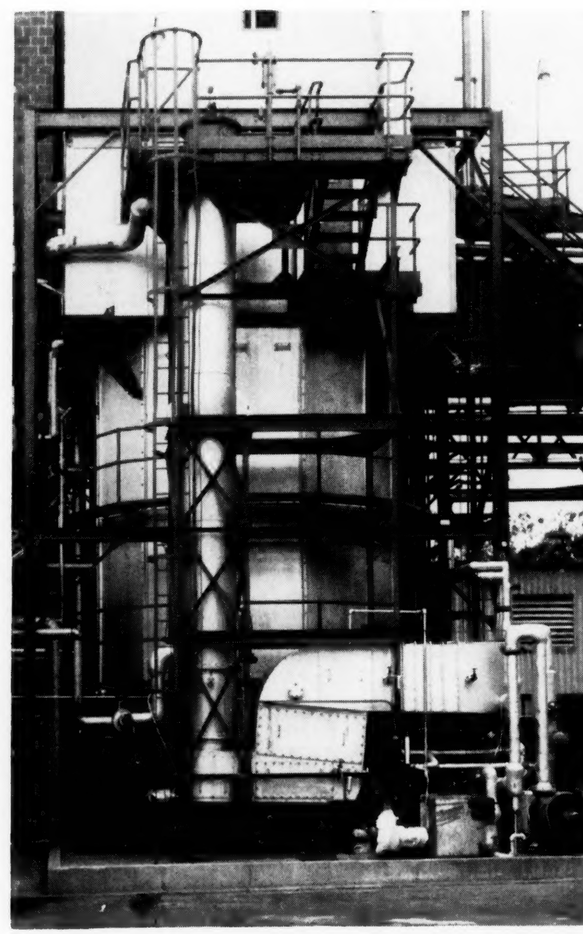
Right now most of its equipment is rubber-lined steel including pipes and pumps. Centrifuge screens are also of rubber. The fermentation and holding tanks, however, are lined with baked-phenolic resin. And a clarification tank is acid-brick lined while drying trays are of plastic.



1 FERMENTER: Twenty-thousand-gal., water-jacketed tanks, each with a 1,000-gal. seed tank, run at 26-28 C., pH 6-7 for 60-70 hr. to produce chlortetracycline-rich mash.







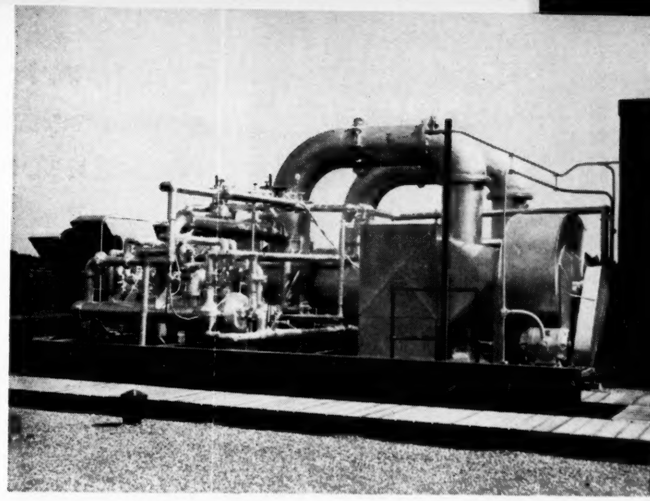
ted
C.,
ash.

2 **HOLDING TANKS: Fermentors feed mash as needed to these four 20,000-gal. tanks on a batch basis. They, in turn, are tapped for a continuous flow to rest of the plant.**

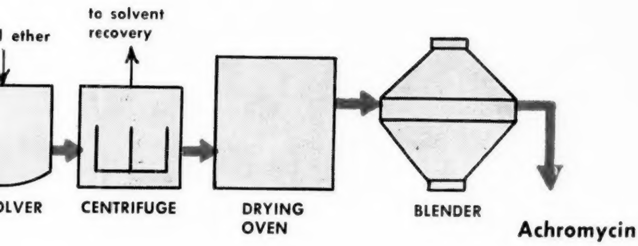
3 **TURBO DRYER: After mash is filtered and butanol has leached out Aureomycin, solids—still retaining some antibiotic activity—are dried and marketed for animal feeds.**

5 F
d
Dechlo

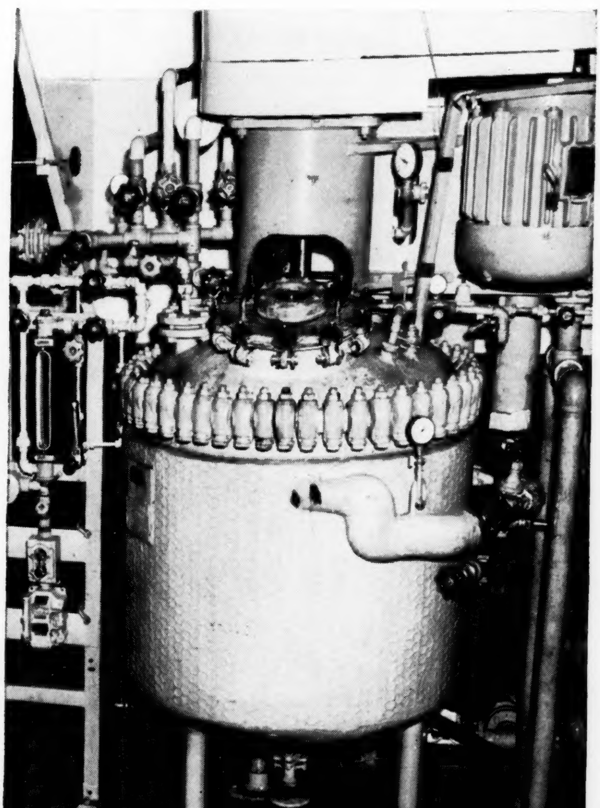
XUM



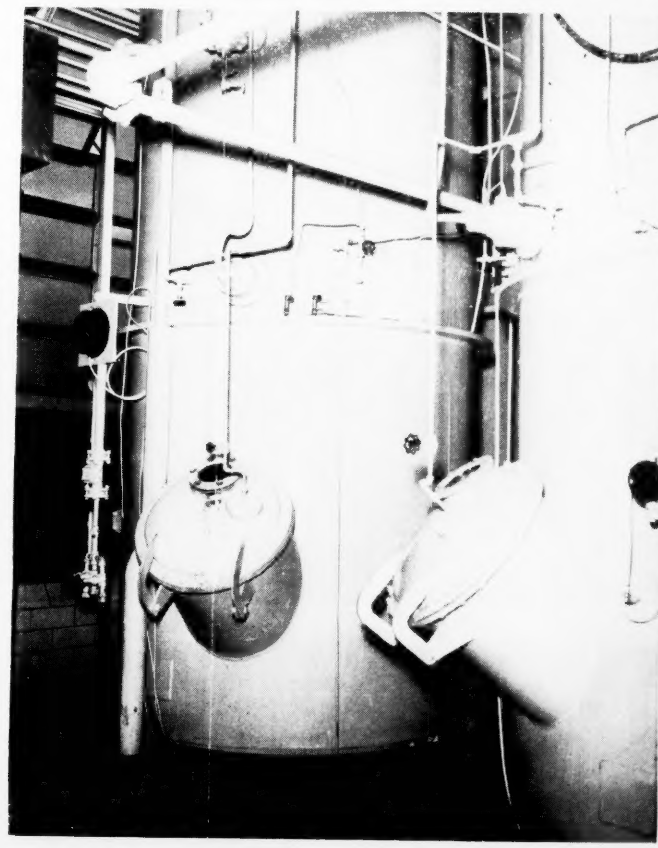
4 FLASH EVAPORATOR: Butanol is flashed from Aureomycin solution to crystallize out the antibiotic.

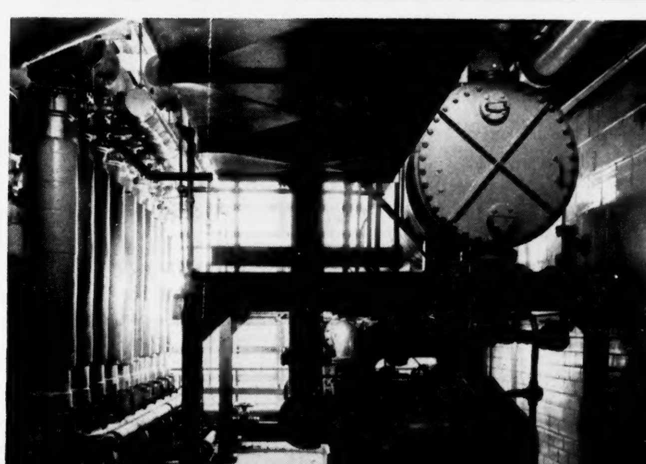


has
me
ds.



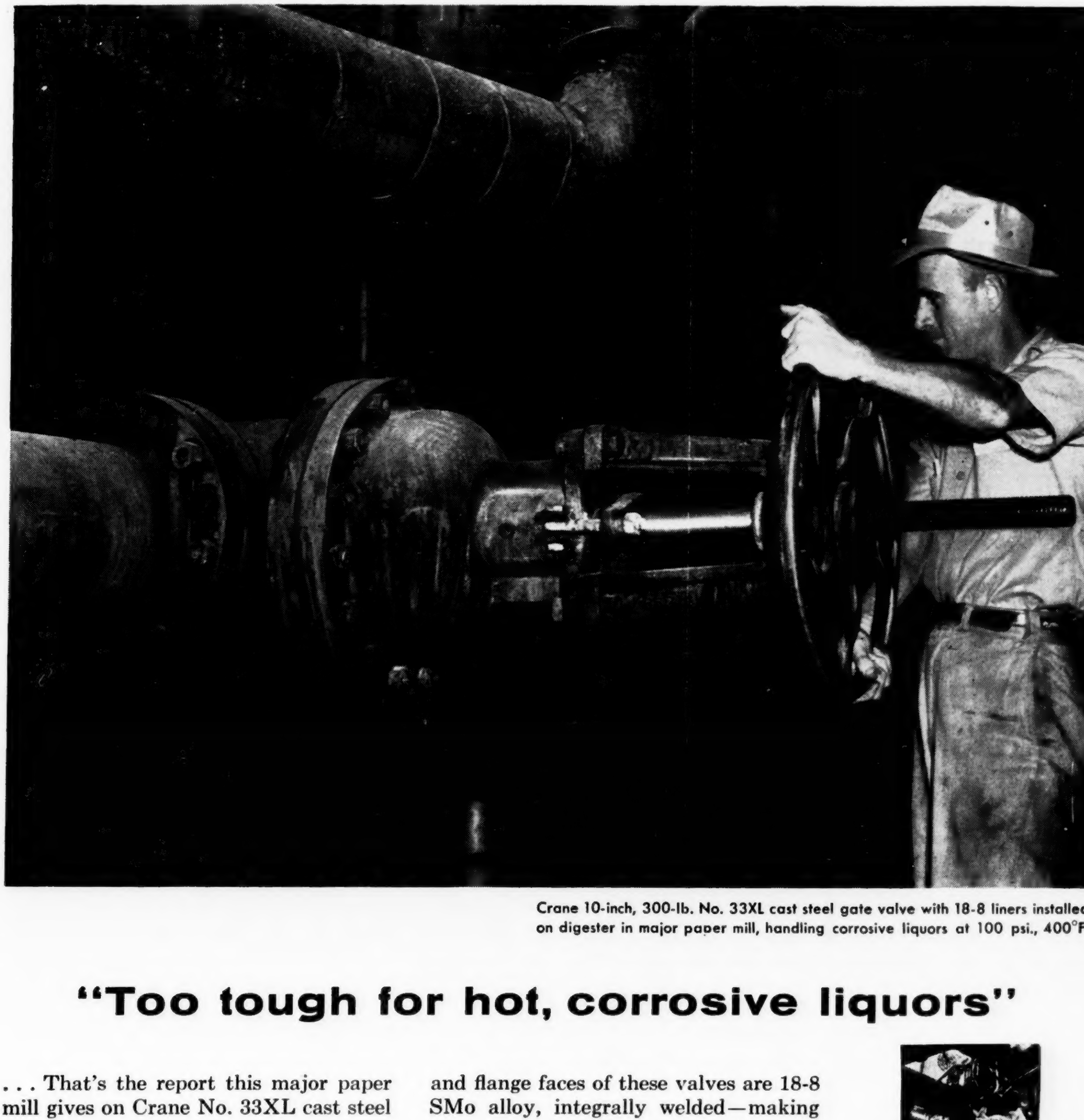
5 REACTOR: Aureomycin-glycol ether solution, palladium-on-carbon catalyst enter hydrogen-filled reactor. Dechlorination, hydrogenation produce tetracycline.





XUM

These Crane Valves Excel on Secondary Digester Blowdown



Crane 10-inch, 300-lb. No. 33XL cast steel gate valve with 18-8 liners installed on digester in major paper mill, handling corrosive liquors at 100 psi., 400°F.

"Too tough for hot, corrosive liquors"

. . . That's the report this major paper mill gives on Crane No. 33XL cast steel gate valves.

Up to 6 years ago, the mill was forced to replace secondary digester blowdown valves on every shutdown. Corrosion worked the body seat rings loose, made valve closure impossible.

Why did these Crane 33XL valves eliminate this costly maintenance problem? Because the body seat rings, liners and flange faces of these valves are 18-8 SMo alloy, integrally welded—making them tough enough to withstand the hot, corrosive liquors.

When you buy valves on price alone—or because they "look good enough"—you're gambling with your production. Be sure: choose your valves and fittings from the big, complete, strictly quality Crane line—first choice of industry for a century.

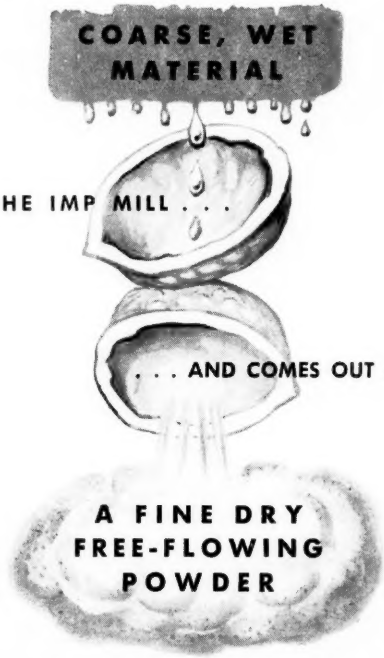
You may spot cost-saving ideas in this book of "Valve Performance Facts"—32 case histories throughout industry. Ask your Crane Representative, or write for a copy.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

XUM



COARSE, WET MATERIAL
A FINE DRY FREE-FLOWING POWDER

Chemical Engineering

Practice

MARCH 1957

Department Index

TODAY'S FRONTIERS IN . . .

High Temperature Technology

Along a broad frontier, high-temperature experts are probing for a major breakthrough that will open a new broad vista of processes and products for mankind.

N. K. HIESTER, F. A. FERGUSON, N. FISHMAN
Stanford Research Institute

WHY DO the chemical process industries not make greater use of the high end of the temperature spectrum? Obvious reasons are: available materials of construction have restrictive limitations; there are difficulties in heat transfer; cost of thermal energy is too high; and there is a lack of sufficient fundamental information about high-temperature chemistry so that chemical reactions of interest cannot be easily predicted.

Despite these reasons for inaction, various chemical engineers have felt a growing conviction for several years that chemical processing could and should use high temperature increasingly.

It was this conviction that produced the Stanford Research Institute-University of California High Temperature Symposium in June 1956. And the same outlook has sparked the writing of this report.

High temperature is a relative term. From a chemical engineering viewpoint, this discussion will treat temperatures above 2,500 F. as high temperature. This range will exclude, in general, most of the common processes in the chemical industry today.

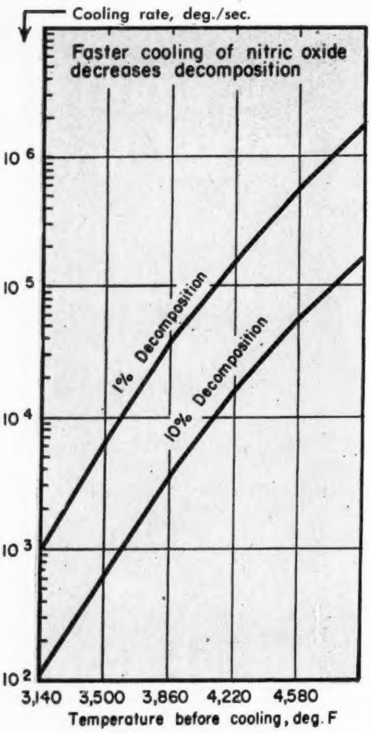
More important than the question of where to set the lower limit is how you define temperatures above the region where you can use a thermocouple. Platinum-platinum rhodium, for instance, can only be used up to 2,800 F.

Of course, you may measure temperature by line-reversal technique or with a pyrometer. But as Carsten Steffens points out in a special paper on temperature,[2] it doesn't matter how you measure temperature or whether it is correct as long as you determine it with a consistent technique in a consistent manner. Normally, temperature is only a parameter used to describe a system and the actual value becomes unimportant.

High-temperature technology may be subdivided into: (1) methods to achieve high temperatures; (2) materials to contain high temperatures; and (3) processes carried out at high temperatures. We shall follow this breakdown throughout our discussion of the past and present status of high-temperature technology and its future potential.

Each application of high-temperature technology involves unique design problems. For instance, factors that must be considered and integrated into the final design include the choice of a container for the reactants; its stability in the particular environment; and matching of method for achieving high temperature, process desired and available materials.

Meet your three SRI authors on pages 327, 329 and 330.



Early Processes

Very few commercial processes operate at temperatures above 2,700 F. Rather, the majority are found in the range 1,500-2,200 F. Actually, the advent of the electric furnace as a processing tool shortly after the turn of the century, led to the basic processes which constitute the greater portion of present-day, high-temperature production of compounds.

Along the way, several high-temperature processes were conceived and executed that either failed to succeed initially or failed to survive after a period of seemingly successful operation. Among these are fixation of nitrogen by the electric arc, the Wisconsin thermal or the Serpek processes; reduction of magnesia by the carbothermic process; and production of alumina from low-grade bauxite by the Hall process.

Nitrogen Fixation

Probably the most well-known of these unsuccessful processes are those that try to fix nitrogen in the form of nitric oxide. This high-temperature gas reaction is carried out either by the arc processes which supply electrical and thermal energy by electric arc, or by the Wisconsin process where the thermal energy from a gas flame is transferred to the reacting air through the use of refractory pebble beds.

A great deal is known about the thermodynamics and kinetics of the reaction.

$$N_2 + O_2 \rightleftarrows 2NO$$

In fact, so much is known that you can calculate the recoverable quantity of NO from the heating time, temperature and cooling rate.[3] These data are plotted here.

Electric-Arc Processes — Many variations under different names operated on both sides of the Atlantic until the 1930's and are well described in the literature.[4,5]

Air was passed through an arc or grouping of arcs which heated the gases. Product gases were chilled subsequently. Then, nitric oxide was oxidized partially or completely and scrubbed out of the effluent gas stream to produce either nitric acid, calcium nitrate or sodium nitrite, depending upon which process was used.

The method used to spread the arc in the Birkeland-Eyde furnace is shown, p. 240. Alternating current applied to the copper electrodes forms the fan-shaped arc by application of a constant, electromagnetic field. "The discharge thus has the appearance of a luminous wheel filling the space in a narrow circular chamber."

After striking the arc, the air is withdrawn from the reaction chamber and scrubbed with water to form nitric acid.

Many reasons have been advanced for the failure of this process. Primarily responsible for its decline were competition from a revived Chilean nitrate industry and development of new synthetic ammonia and ammonia oxidation processes.

But power cost also was an important contributing factor. Even though 1.5-mil power was available to the American Products Co. plant at LaGrande, Wash., shortage of low-cost "dumped" power kept the plant from resuming operations after it was destroyed by fire in 1927.[5]

Except for experimental operations, two large plants at Notodden and Rjukan, Norway, operated the last arc process for fixation of atmospheric nitrogen. These fell into disuse during the early '30's when they were replaced by ammonia-oxidation plants consuming less power.

Reactivation of the arc processes is well within the scope of present-day technology. Materials of construction were not critical, since the large flow of air kept the walls below 2,200 F.

High first cost is an important factor. But availability of low-cost power coupled with more economical recovery methods would certainly arouse renewed commercial interest.

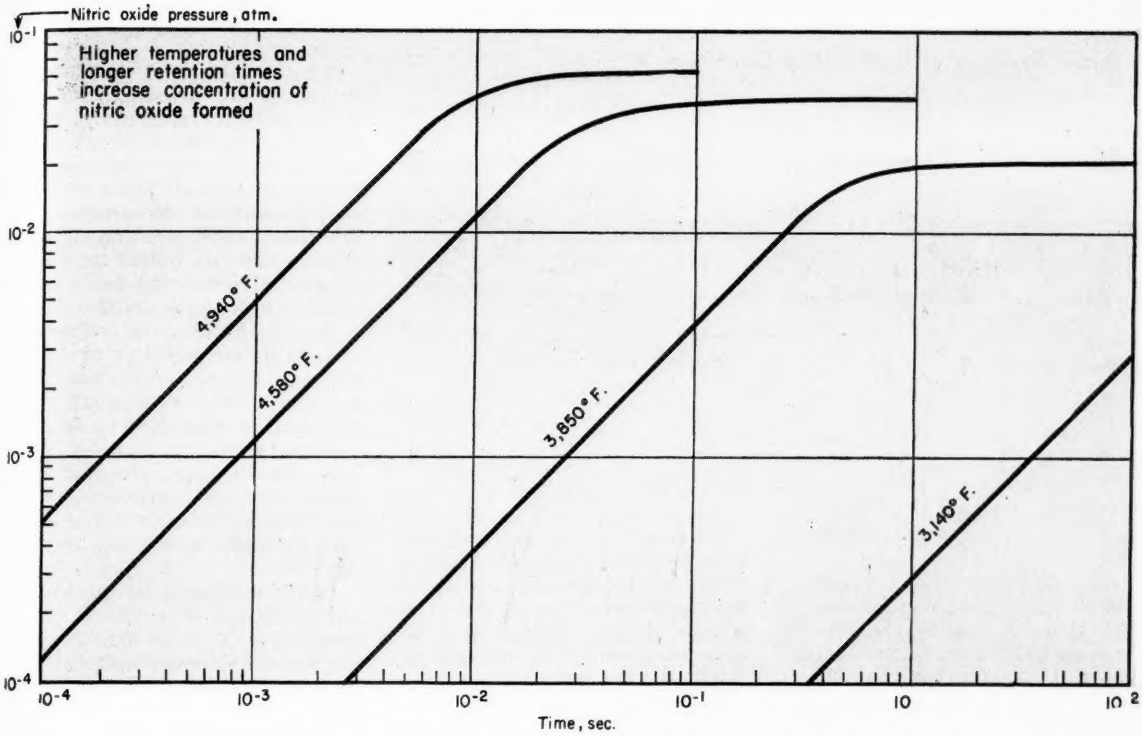
Probably the best possibility for reactivation of the electric-arc gas reactor lies in adapting it to some process that will yield a more economically attractive product, such as cyanogen.

Wisconsin Process — The literature has devoted considerable space to the Wisconsin process, a thermal method for fixation of atmospheric nitrogen. The University of Wisconsin gave the greatest impetus to this process.

Later, support from the Wisconsin Alumni Research Foundation, U. S. Army Ordnance and Food Machinery & Chemical Corp. brought the process to the stage where a 40-ton-per-day nitric acid plant operated on feed from a gas-fired pebble-bed furnace at Sunflower, Kan. This commercial-scale plant operated about 65% of the time between May 1953 and August 1954. Process details are readily available in the chemical engineering literature.[6,7,8]

Immediate cause for shutting down the Sunflower plant was the severe breakage of pebbles which plugged the pebble beds and chutes. Because of this difficulty, continuous operation was not possible at the 4,000-F. design temperature, although considerable operating experience was gained at about 3,800 F.

An earlier pilot plant operated continuously for eight months at 4,000 F. using high-quality, high-cost magnesia pebbles which were produced on a pilot scale. The internal furnace refractory, also of high-purity magnesia, was damaged seriously during the first emergency shutdown, but appeared to heal upon subsequent firings. At



the time of the final furnace shutdown, the brick work was found to be in excellent condition for further operation.

As far as materials of construction are concerned, the furnace was shown to be feasible economically. However, it became a process of the past because of economic considerations.

Development of the process was spurred by World War II. Construction of such a plant would have required little diversion of machine-tool time. And it would have helped relieve the drain on the short supply of ammonia for the manufacture of nitric acid needed for munitions.

After the war, however, synthetic ammonia production increased and ammonia oxidation processes progressed technologically. As a result, the Wisconsin process became less and less attractive.

Major economic failing of the Wisconsin process is the high cost of concentrating and recovering the nitrogen oxides in the furnace product gas. Development of a new low-cost recovery method would make the over-all process competitive and attractive, even in today's market. The exigencies of war and a short ammonia supply might also dictate reactivation of the Wisconsin process.

Serpek Process—Hydrolysis of aluminum nitride to ammonia was practiced by the French during World War I.[9] The Serpek process produced aluminum nitride from alumina and coke in a nitrogen atmosphere at 3,300-3,500 F. Then, the resulting nitride was hydrolyzed to form aluminum hydroxide and ammonia.

$$3C + Al_2O_3 + N_2 \rightarrow 3CO + 2AlN$$
$$AlN + H_2O \rightarrow Al(OH)_3 + NH$$

First versions of the process used a heated rotating reactor, but later patents favored electric arcs to reach the required reaction temperatures.

One avowed reason why the process failed was the large amount of aluminum hydroxide produced. This may be true, but a more likely explanation is the extreme difficulties encountered in handling alumina-coke mixtures, particularly if the alumina contained appreciable quantities of silica impurity.

These difficulties are enumerated in a survey[10] of the Serpek process undertaken at the Fixed Nitrogen Research Laboratory, Washington, D. C. and include: (1) formation of carbides in zones having high carbon concentrations; (2) formation of Al-Fe-Si alloys; (3) fusion of bauxite in carbon-deficient zones.

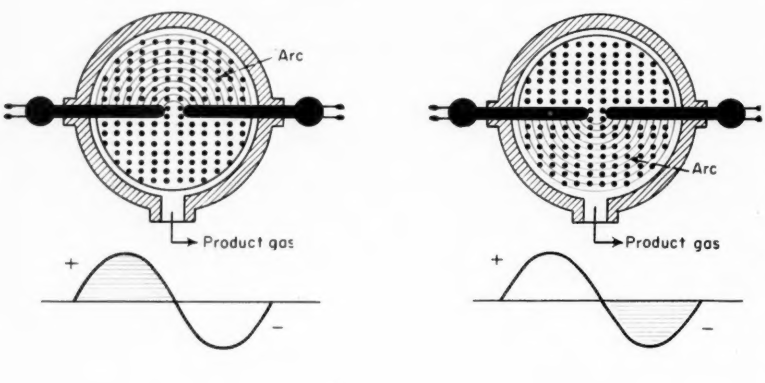
Reactivation of the Serpek process seems remote, for two reasons: A great deal more would have to be known about the phases and components in the system Al_2O_3-SiO_2-C-N_2 at high temperatures; and in order to be competitive in today's economy, the aluminum hydroxide would have to be the main product with ammonia as the cushion.

Carbothermic Magnesium

Thermal reduction of alkaline and alkaline-earth compounds has been contemplated for many years. One such process,[11,12] operated by Permanente Metals Corp. at Permanente, Calif. during World War II, produced magnesium by the reaction:

$$MgO_{(s)} + C_{(s)} \rightarrow CO_{(g)} + Mg_{(g)}$$

Arc oscillates in Birkeland-Eyde chamber



It was necessary to attain temperatures in excess of 3,300 F. before the reaction would proceed at reasonable rates.

As practiced in the Permanente Metals plant, heat was supplied to the magnesia feed by electric arcs in a graphite-lined furnace. Gaseous products leaving the furnace were shock-cooled by mixing with natural gas. Magnesium present in the resulting mixture was separated from the gases, pelleted and resublimed under vacuum in electrically heated retorts.

These latter steps were necessary to increase the particle size from the original 0.2-0.6 microns to a more readily handled size, and to separate the magnesium from magnesia and carbon formed by the reverse reaction during the chilling period. Carbon was also formed by decomposition of the natural gas coolant.

The plant was shut down after the war, and one can only guess why it was not reactivated. As in the Wisconsin process, the inference is that the furnace portion of the process proved feasible, but the recovery and purification problems required further research. Use of high temperature in itself was no problem, except in freezing the products quickly to prevent formation of magnesia and carbon.

Hall Process

The Hall process,[13] an early attempt to replace the modified Bayer process for production of alumina from low-grade bauxite, is similar to the current process for fused alumina.

$$Fe_2O_3 + SiO_2 + Al_2O_3 + 5C \rightarrow Al_2O_3 + 5CO + FeSi$$

Granular bauxite and coal were first sintered at about 1,800 F. After cooling and introduction of additional coke, the mixture was smelted at about 4,500 F. in a furnace using Söderberg electrodes to supply the heating energy.

The melt was contained in a shell of the unmelted charge. Pure alumina was blown from the top of the furnace; ferrosilicon and ferrotitanium were tapped from the bottom. A British adaptation recovers the fused alumina by tapping, rather than blowing, the molten alumina from the top of the molten mass.

The only thing wrong with the Hall process is the fact that it cannot compete on either purity or cost bases with the relatively simple sodium hydroxide leaching in the improved Bayer process.

Present Processes

In Table I are listed several processes which are typical of present-day high-temperature technology. They are organized, in general, according to the method used to achieve the reaction temperature.

Electrothermal Processes

Probably the best known of the high-temperature processes are those which employ the electric furnace.[4] There are many variations of the electric furnace, most of them designed for specific processes. Generally, however, they can be classed as direct or indirect resistance, direct or indirect arc, or induction furnaces.

Direct heating, with either resistance or arc furnaces, entails the use of the process material as an integral part of the circuit. Indirect heating, on the other hand, requires the use of elements other than the process material to produce the electrical resistance or the arc. Furnaces, which are heated by a combination of direct or indirect arc or resistance elements, are also in use.

The limitations of refractory furnace linings need not be felt in electric furnace applications. In many instances, the material to be processed is contained by its own unmelted shell.

Phosphorus—The phosphorus industry has three processes which should be included in a review of current high-temperature technology.

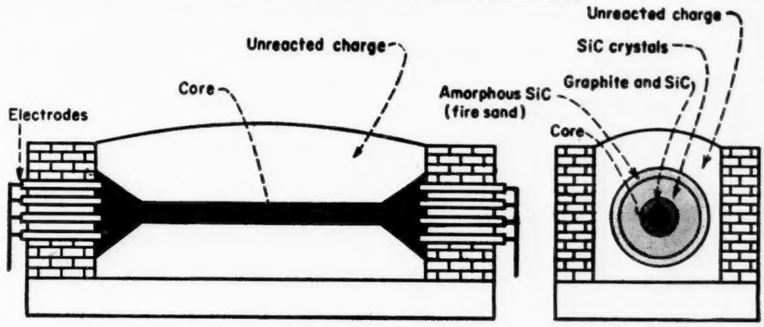
Defluorination of phosphate rock has undergone much study. Processes have been developed which employ calcination or fusion at temperatures ranging from 2,500 to 2,900 F.[14]

Reduction of phosphate rock, for the production of phosphoric acid or other phosphorus compounds, is accomplished continuously by either blast or electric furnaces at about 2,400 F.

High Temperature Processes—Table I

	Temperature Deg. F.
Electrothermal	
Phosphate rock defluorination and reduction	2,500–2,900
Production of carbides	
Silicon	4,250
Boron	4,550–4,700
Calcium	3,600
Production of graphite	4,000
Conversion of barium carbonate, to the oxide	3,600
Fused alumina, or Alundum	3,600–4,000
Induction heating	6,500
Calcination	
Portland cement	2,500–2,700
Magnesia dead-burning	3,300–3,450
Metallurgical	
Blast furnace	2,700
Electric furnace	3,400
Combustion	
Phosphoric acid	3,600
Acetylene production	2,400–2,700

Silicon carbide forms around core of resistance furnace



Furnace freshly charged **Reaction completed**

Combustion of elemental phosphorus for production of phosphoric acid completes the trio, and is discussed under "combustion processes" below.

Defluorination of phosphate rock makes the P_2O_5 content of the rock more soluble and, hence, more readily available as a fertilizer. The reaction requires moisture, either from the products of combustion or as steam added in the electric furnace. Furnace linings usually consist of a common refractory brick, since no unusual corrosion or high-temperature problems are encountered.

Electric furnace reduction of phosphate rock consists of the volatilization of the element from its compounds under reducing conditions. Here again, no unusual problems are encountered, and the furnace is usually lined with carbon and/or refractory brick and enclosed in a water-cooled shell.

Carbides—Production of the metallic carbides from the oxides constitutes a major segment of commercial activity in high-temperature technology. Silicon carbide, SiC, is made commercially in a batch process by heating a suitable charge of carbon, coke and silica sand in a resistance furnace.

A sketch of the silicon-carbide furnace, above, shows the product-formation zones. The resistance core usually is composed of granular coke or graphitized material and is operated at about 4,250 F. or above the dissociation temperature of silicon carbide (m.p. about 3,800 F.).

When the furnace is unloaded, a ring of graphite usually is found around the core. This in turn is surrounded by silicon carbide which formed at about 3,350 F.

The silicon-carbide crystals at the outer edges of the furnace, where the temperature fell below 3,259 F. pass into a region of firesand, or amorphous silicon carbide. This is surrounded by a shell of unconverted mix which did not rise above about 2,900 F.

Manufacture of boron carbide, B_4C, is similar to the SiC process. The furnace charge, consisting of dehydrated commercial boric acid and high-purity coke, reacts in a resistance furnace at 4,550 to 4,700 F. Carbide forms when the innermost zone becomes molten.

The initial charge consists of residues from previous runs piled as a resistance core between the electrodes. Retaining walls of the same material serve as furnace-liner material.

Calcium carbide, CaC_2, usually is produced continuously in a tapping furnace in which the direct arcs are buried deeply in the charge of lime and coke. In operation, the furnace is really a smothered-arc resistance type, in which heat is produced by arcing between the electrodes and charge, and by resistance heating of the charge itself. The refractory furnace lining is far enough from the electrodes to avoid damage by the molten charge.

To provide continuous operation, the electrodes usually are the Söderberg type, which are formed continuously by baking a soft carbon paste with waste heat from the furnace and are added to the furnace as needed.

Though calcium carbide decomposes above about 2,730 F. it forms faster than it decomposes at the furnace operating temperature of about 3,600 F.

Graphite—Graphite is produced by a process very similar to that for silcon carbide. In fact, it was formation of graphite observed near the core in an early silicon-carbide furnace that prompted the development of the graphite process used today.

Anthracite coal, containing about 6% ash (largely silica, alumina and iron oxide), is heated to more than 4,000 F. in an electric resistance furnace and converted to practically pure graphite. The presence of a relatively small amount of carbide-forming material is required to bring about this large conversion. The carbides are decomposed and the metals and metalloids are distilled off.

Alundum—In the production of fused alumina, or Alundum, the electric furnace is charged preferably with impure bauxite which has been dried and calcined; coke; and additional metallic oxides, if required. During the 3,600-4,000-F. fusion, ferrosilicon containing aluminum, titanium, phosphorus and sulfur is reduced out of the charge and drawn from the bottom of the furnace. The pure, fused alumina is then cooled and withdrawn from the furnace as a block.

Furnace is generally lined with carbon-block refractory. In some furnaces, only the bottom is so lined, while the sides of the furnace consist of a water-cooled steel shell. A British variation operates by continuously tapping the molten alumina from the top of the molten mass.

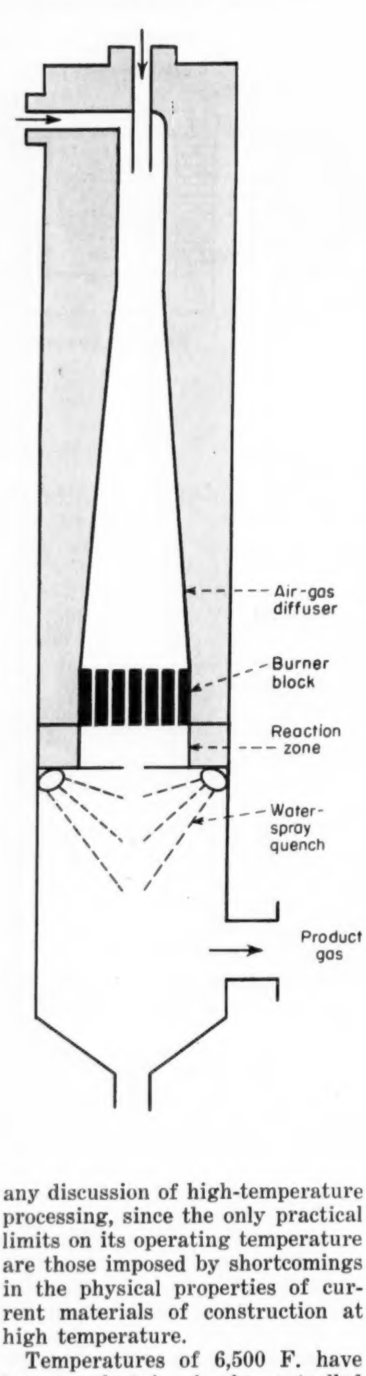
Barium Oxide—Still another commercial electric furnace process converts barium carbonate to the oxide. Here, the furnace charge consists of the carbonate and carbon. The dissociation proceeds according to the reaction

$$BaCO_3 \rightleftarrows BaO + CO_2$$

Vapor pressure of CO_2 over $BaCO_3$ is quite low. Reaction rate is improved by removing the CO_2 as soon as it is formed through reaction with carbon in the charge to form CO. The melt, or reaction, occurs in a container of unmelted charge material. Recent advances in this process provide for continuous operation at temperatures in excess of 3,600 F.

Induction Heating—The induction furnace must be included in

Sachsse Process Burner



any discussion of high-temperature processing, since the only practical limits on its operating temperature are those imposed by shortcomings in the physical properties of current materials of construction at high temperature.

Temperatures of 6,500 F. have been reached in closely controlled laboratory furnaces. Commercially, it is used primarily in metallurgical processing of nonferrous alloys, sterling silver, special steels, corrosion-resistant alloys, magnetic materials and a large variety of experimentally produced metals.

Crucible for the melt must be a conducting material, such as graphite or the metallic refractories, since it serves as the secondary coil which receives the induced current.

In some cases, where crucible materials are not satisfactory because of chemical reactivity of the melt or temperature limitations, the problem is circumvented by suspending the mass of molten material in a magnetic field.[15] As yet, however, this levitation technique is limited to small melts.

It's interesting to note that in most of the current commercial electric furnace processes the reaction is carried out in a crucible or furnace lining of the unreacted charge.

Even should there be suitable high-temperature refractories to contain these reactions, it is difficult to see how the processes described could be improved technologically. With such refractories, reactants might be heated by methods other than electrical to reduce maintenance and replacement costs so that existing processes become more profitable.

Calcination

Production of cement by calcination probably is one of the oldest and best known of the processes requiring high temperatures (2,500-2,700 F.). A mixture of feed materials is calcined in a kiln at temperatures that will fuse the mass, allow certain reactions to occur, dehydrate the clays and decarbonize the limestone.

The kiln may be fired with oil, gas or pulverized coal and air preheated by the product clinker. Severe abrasion and chemical attack at high temperatures pose a kiln lining problem, but alumina brick or clinker itself has been found to be satisfactory.

Dead-burning magnesia is a more recent calcination process and employs temperature from 3,330 to 3,450 F. This process develops a permanent bond in the magnesia by partial vitrification to produce a more stable form of the refractory. The kiln usually is lined with dead-burned magnesia brick.

Metallurgical Processes

High-temperature processes in the metals industries include pyrometallurgical and electrothermal processes for winning metals from their ores or concentrates, for refining the metals and for alloying.

Pyrometallurgy deals with chemical reactions at high temperatures. Necessary heat for the processes comes from combustion of various feuls.

Some high-temperature electrothermal processes, in which the heat is supplied by electricity, have already been described. Electrometallurgy includes additional processes for smelting, refining and alloying metals.

In roasting or sintering ores or their concentrates, temperatures above 1,850 F. seldom are encountered. In smelting operations, however, temperatures must be considerably higher to produce the liquid products: molten crude metal and slag in reduction smelting; liquid matte and slag in matte smelting.

The great bulk of all iron ore goes directly to iron blast furnaces, where it is smelted to pig iron. The hottest zone in the blast furnace is about 2,700 F. where the molten slag flows and can be tapped from the furnace.

Similar temperatures are encountered in most smelting operations which depend upon heat to form and fuse the slag. These temperatures are regulated to a minimum level by fluxing, in consideration of temperature limitations for the furnace liner.

Converting liquid pig iron into steel, or Bessemerizing, and the conversion of mattes are processes where the heat is supplied solely by oxidation of part of the liquid charge. Electric furnaces used as converters frequently operate at temperatures up to 3,400 F.

Electric smelting has not been used very widely, mainly because electrical heat is more expensive than fuel heat in most cases. Such processes have been confined almost exclusively to certain regions in Europe where inexpensive hydroelectric power is available. However, in the United States, the electric process has won acceptance for the manufacture of high-quality carbon and alloy steels, replacing the established crucible process almost entirely.

Maximum temperatures achieved in these pyrometallurgical and electrothermal processes usually range from 2,700 to 3,500 F. Refractories such as silica brick, fireclay brick

and magnesite are commonly used.

Though it's unlikely that elevation of maximum temperatures would improve process, furnace linings and accessory materials with higher temperature tolerances would certainly reduce down time and maintenance costs.

Combustion Processes

Elemental phosphorus is burned at about 3,600 F. to form the pentoxide for production of phosphoric acid. Molten phosphorus, air and atomizing steam are metered in separate streams to the burner nozzle. Temperature must be maintained at a high level to prevent formation of metaphosphoric acid.

Corrosiveness of P_2O_5 vapors at the reaction temperature has caused additional processing problems. Usually, the reaction is carried out in a vertical combustion chamber built of graphite blocks and cooled by water distributed on the exterior.

Poor temperature control and excessive maintenance have been the major disadvantages of this design. To circumvent these problems, Shea Chemical Co. has constructed a large, horizontal, quonset-hut-shaped combustion chamber of graphite blocks with a burner nozzle at each end. This design provides greater structural stability as well as more uniform distribution of cooling water for improved temperature control.

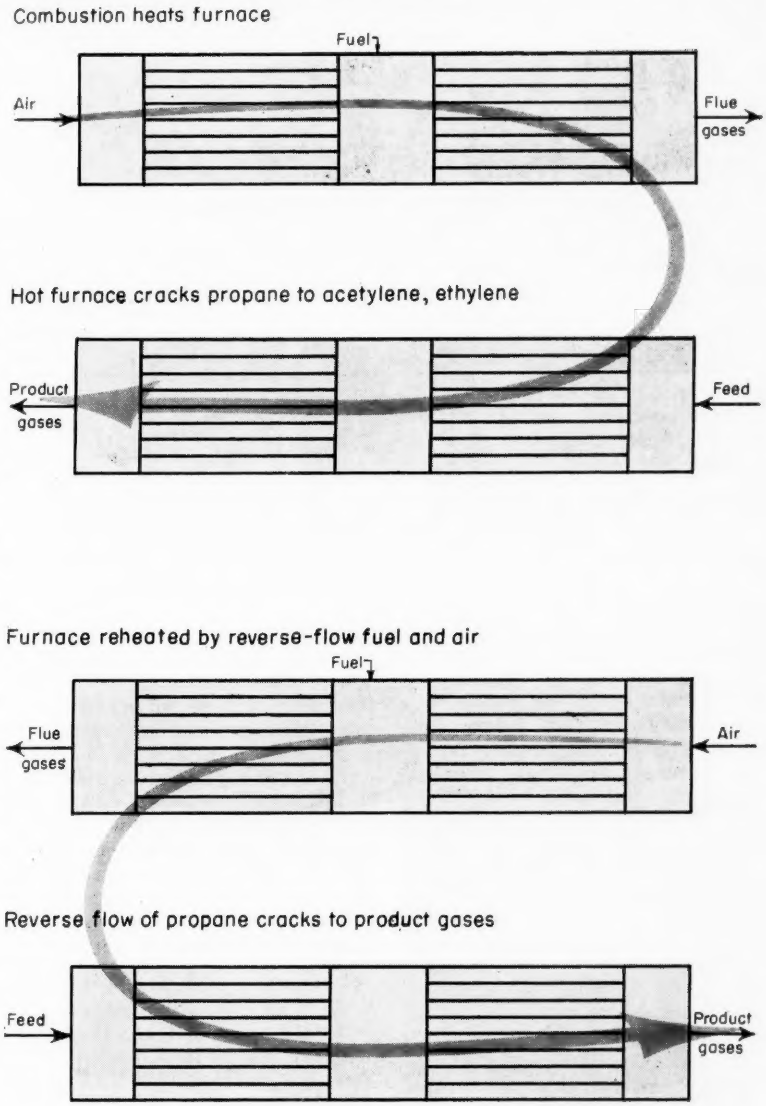
Virginia-Carolina Chemical Corp., on the other hand, uses a vertical water-jacketed stainless-steel combustion chamber. With this design, the reaction can be carried out under pressure, and a smaller chamber can be used.

To minimize formation of metaphosphoric acid in this cold-wall combustion chamber, the burner is pointed downward to vaporize the meta acid which has formed in a layer at the bottom and thereby balance that which forms in the cooler combustion zones.

The most recent commercial high-temperature process is production of acetylene by partial oxidation of natural gas. In the conversion of methane to acetylene, the free energy becomes negative above 2,400 F.

In the Sachsse process, heat for the reaction is furnished by exothermic oxidation of part of the methane. After being preheated to

Complete Cycle for Wulff Furnace



1,000 F., the gases are mixed and passed through ports in an alumina block to the reaction zone, as illustrated on preceding page.

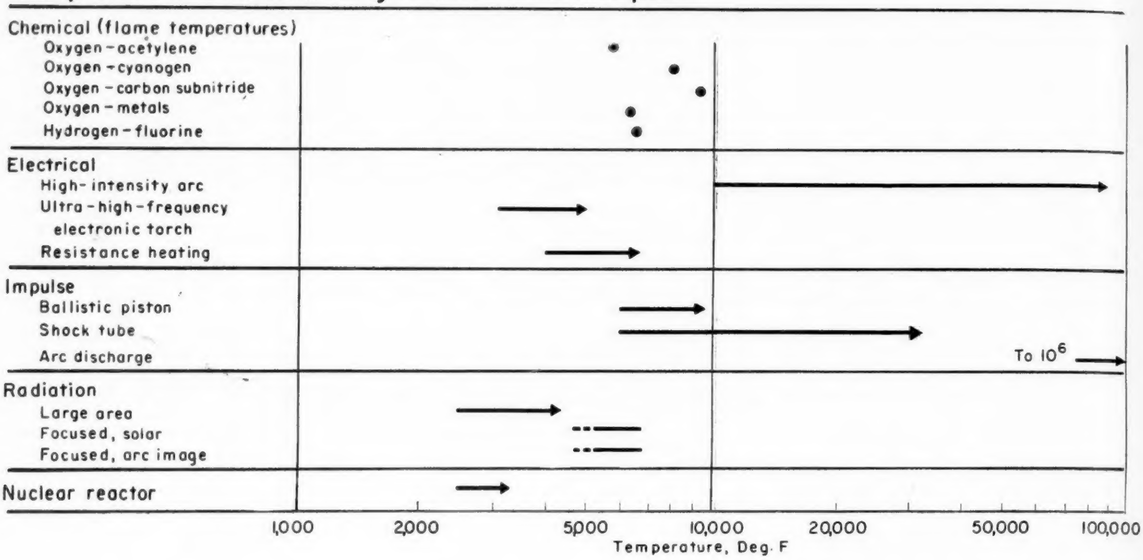
The burning gases reach a temperature of about 2,700 F. and are then rapidly quenched with a water spray to about 160 F. Product gas contains about 8% acetylene plus ethylene, carbon monoxide and hydrogen. Organic products are removed. The remaining gas is available for use as feed gas to the synthetic methanol or ammonia processes.

In the Wulff process for producing acetylene, now operating at the Wulff Process Co., Maywood, Calif.,[16] high reaction temperatures (1,800-2,400 F. depending on the feed hydrocarbon) are attained by cyclic operation as shown in illustration above.

First, in the heat cycle, the furnace brick checkerwork is preheated by an air-gas flame. During the make cycle which follows, this checkerwork heats feed to the cracking temperature.

The Wulff furnace actually is divided into halves. A complete cycle for each half consists of two heats

Temperatures Reached by Various Techniques



and two makes. A rather complex valving and piping arrangement provides continuous operation of the furnace.

Checkerwork and bricks immediately adjacent to and facing the furnace are 99% alumina. Surrounding the checkerwork are suitable insulating brick encased in a steel shell.

Products from this furnace, under proper operating conditions and using a propane feed, include about 10% acetylene with lesser amounts of ethylene and other unsaturates. Ammonia synthesis gas also is a product of this process.

Several new acetylene-from-hydrocarbon installations employ the Sachsse process. However, in the future the Wulff process may be used more widely than the Sachsse process because ethylene is produced simultaneously from feeds other than methane (e.g. gas oil, propane), and need for tonnage oxygen is eliminated

Outlook—Methods

There are many ways to obtain high temperatures, but only a few are used in present-day technology. Chemical methods, such as the burning of phosphorus and combustion of fuels, and electrical means such as the arc and resistance furnaces, have been discussed.

Other available means of obtaining high temperatures are illustrated above. But at this time, they are found only in very limited commercial application or in the laboratory as a process development, a research tool or a scientific curiosity. As process needs arise and container materials become available, these methods certainly will find wider technological application.

Chemical Methods

Combustion of fuels is a foundation block of high-temperature technology. Coal, oil, or gas burned with air or oxygen can provide energy at temperatures up to only 4,500 to 5,000 F.

Use of ozone instead of oxygen will usually raise the flame temperature about 450 F. Maximum flame temperatures reached depend upon fuel-oxidant ratios and the amount of inert diluents, such as nitrogen, which are present.

Commercial availability of new fuel materials, such as carbon subnitride, would raise the temperature to about 9,500 F. Table II shows some typical combustion reactions and the flame temperatures achieved.

A barrier which limits the maximum temperature available from chemical reactions is the temperature range where molecular species dissociate. Combustion reactions which produce only carbon monoxide and nitrogen reach the highest flame temperatures because these compounds have uniquely high dissociation temperatures. Their bond temperatures, or temperatures where standard free-energy change is zero for decomposition to atoms, have been calculated as 13,220 and 12,320 F. respectively.[17]

You can see the reactants should involve only the elements C, O and N at a 1:1 atom ratio of C to O for the chemical reaction to yield the highest flame temperature. The combustion of carbon subnitride, C_4N_2, with oxygen

$$C_4N_2 + 2O_2 \rightarrow 4CO + N_2$$

fulfills this requirement.

Thus, it can be seen that hydrogenated fuels, which produce water during combustion, limit the attainable flame temperature because dissociation temperature is about 5,000 F.

In addition to combustion reactions which yield gaseous products, there are oxygen-metal flames which might prove applicable because of their superior ability to transfer heat.[18] (Heat of condensation of the oxide product is available for transfer to the process.) Perhaps transfer of heat from such a flame to gaseous reactants would prove to be effective processwise. Oxy-metal flames have been used in torches to cut ceramic materials

and metals which cannot be cut by an oxy-acetylene torch.

Recent rapid developments in the fields of jet propulsion and rocketry have placed before the chemical engineer hardware which could open new processing applications for combustion. Large volumes of gases are handled in relatively small reactors with rapid quenching through a work-extraction step, and with power generated optionally as a byproduct.

The gas turbine, because of temperature limitations of current materials of construction, has had only theoretical evaluation as a chemical reactor. Use of ramjets or rocket engines appears more favorable from the standpoint of temperature limitation.[19]

Recent work at Reaction Motors, Inc.[20] resulted in a very favorable yield of nitric-oxide from a rocket engine designed as a reactor. The investigators opined that temperatures of 5,300 to 5,700 F. are feasible for this type of reactor and that development of a decelerating device, such as turbine, will not be too difficult.

Another aspect of rocket combustion as a processing tool may be its use as a specialized burner to supply large quantities of high-temperature combustion products to a process requiring heat. Possibly, combustion of fuel and oxidant in close combination with chemical reactants requiring heat would prove attractive as a continuous process. It is assumed, of course, that there are no problems of interaction between combustion products and reactants and that the value of process product is sufficiently high to offset the cost of fuel and oxidant.

Combustion in the gas turbine or the rocket engine provides attractive processing possibilities. Perhaps elimination of present temperature limitations will make use of these devices more commonplace.

Reaction Temperatures—Table II

Reaction	Flame Temp. F.
$C_4N_2 + 4/3O_3 \longrightarrow 4CO + N_2$	9,470
$C_4N_2 + 2O_2 \longrightarrow 4CO + N_2$	9,010
$C_2N_2 + O_2 \longrightarrow 2CO + N_2$	8,270
$H_2 + F_2 \longrightarrow 2HF$	6,650
$C_2H_2 + 3/2O_2 \longrightarrow 2CO + H_2O$	5,840
$C + 1/2O_2 \longrightarrow CO$	5,840
$C + O_2 \longrightarrow CO_2$	5,210
$H_2 + 1/2O_2 \longrightarrow H_2O$	5,160
$C + Air(O_2 + 4N_2) \longrightarrow CO_2 + 4N_2$	3,810
$C + Air(1/2O_2 + 2N_2 \longrightarrow CO + 2N_2$	2,190

Electrical Methods

The tremendous importance of the electric arc in the process industries is undeniable. The high-intensity arc, generating temperatures above 10,000 F., has already reached commercial development. Still other electrical techniques are receiving much attention as possible processing tools.

One disadvantage of electrical processes is the relatively high cost of electrical energy compared to that obtained from chemical fuels. The days of low-cost or dumped commercial electricity are gone.

On the positive side, arcs can provide temperatures above 9,500 F., the probable upper limit of practical chemical combustion.

The high-intensity arc uses high current density to produce extreme temperatures. Theoretically, the voltage drop shifts from a uniform drop between anode and cathode (present in the normal arc) to a drop concentrated at the anode surface. This high energy then is available to vaporize the anode material which takes off in a long tail flame.

As the current intensities increase, the potential drop, and hence energy transfer, shifts more and more toward the anode crater. As much as 70% of the energy transfer has already been made to occur in this anode region. Quenching the gases in the tail flame (anode material) can also produce freeze reactions not possible at lower temperatures.

Although the temperature of the electrode crater is in the 10,000-F. range, plasma temperatures up to 90,000 F. have been observed in flames emitted from these electrodes in very high-current-density arcs.

Introduction of chemical compounds or gases into these flames already has led to discoveries of new chemical species and unusual properties in the thermal plasma. For example, plasma consisting almost entirely of completely ionized atoms has specific heat and enthalpy that differ numerically from those for ordinary gases by several orders of magnitude.

The electronic torch[21] uses ultra-high-frequency power to dissociate gaseous molecules by passing the gases through an arc discharge. Recombination of these atoms as they leave the torch produces temperatures as high as 18,000 F. in the core and average gas temperatures as high as 5,000 F. Some results have been published on electronic torches used for the fixation of nitrogen.[22]

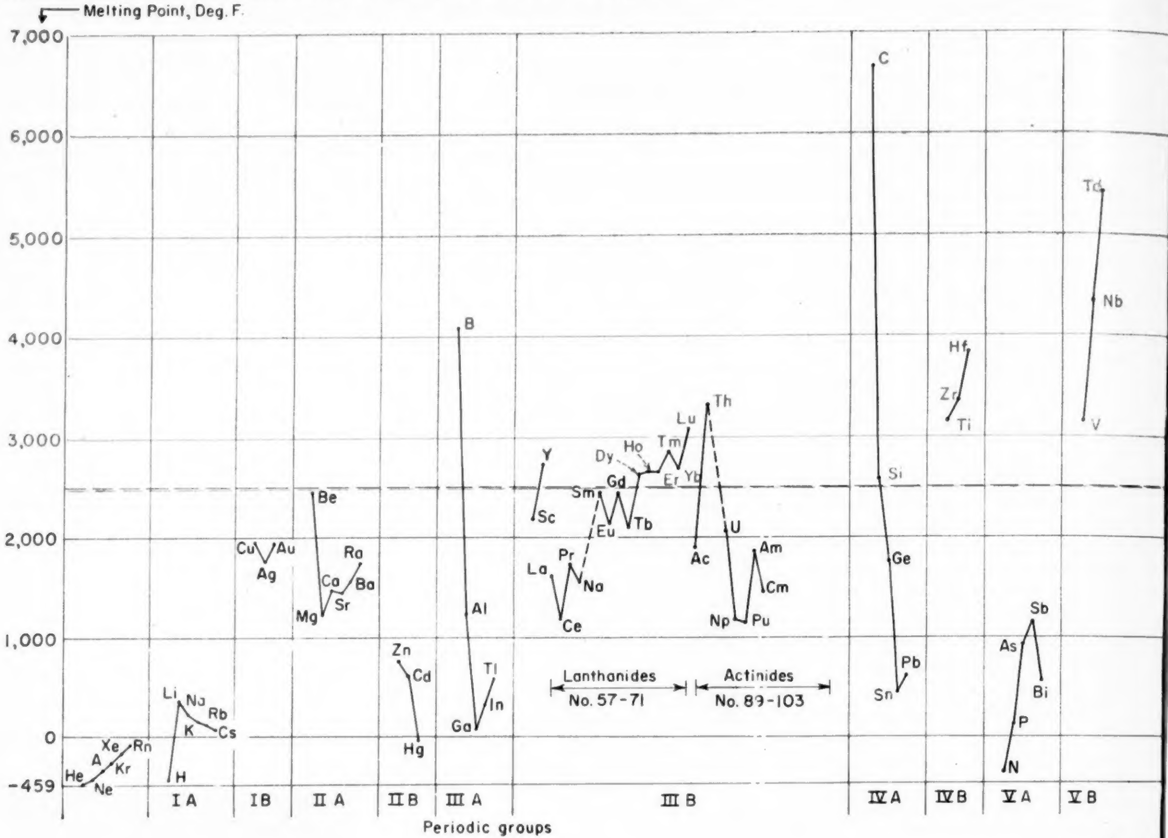
General Electric Co. has marketed an atomic hydrogen torch for specialized cutting and welding applications. It is conceivable that this means of achieving high temperatures will prove to be an adaptable tool for gas reactions. Prime disadvantage is the exceptionally high cost for the power supply equipment. A small laboratory torch requires 5 kw. of power at 915 megacycles.[21]

Oxide resistors have been used for several years as heating elements for high-temperature laboratory furnaces.[23] This type of resistance furnace probably is the most reliable means of reaching temperatures up to 3,600 F. in an oxidizing system. Use of hafnia or thoria could raise the limit.

To reach the highest possible temperature with a solid resistance

TAIL flame from high-intensity electric arc contains vaporized anode material.

How Melting Points of Elements Compare by Periodic Groups



heating element would require use of the highest melting solid material known. This is a four-to-one mixture of tantalum carbide and hafnium carbide, m.p. 7,120 F. The nearest approach to this has been with a tantalum carbide (m.p. 7,015 F.) resistance element in a laboratory furnace. But the high carbon vapor pressure of the tantalum carbide proved to be a disadvantage when operating at such an elevated temperature.

There are no commercial resistor furnaces known to be in use at this time. An improvement in the high-temperature physical strength of the resistor materials would do much to make their use more attractive.

Impulse Methods

Impulse-induced temperatures are the highest non-nuclear temperatures yet produced but they are transitory. Impulse temperatures are created by means of the ballistic piston, the shock tube and the arc discharge.

At California Institute of Technology, B. H. Sage has studied application of ballistic piston reactions such as that between nitrogen and oxygen to form nitric oxide. He has reported temperatures of 8,000 F. and higher.[24]

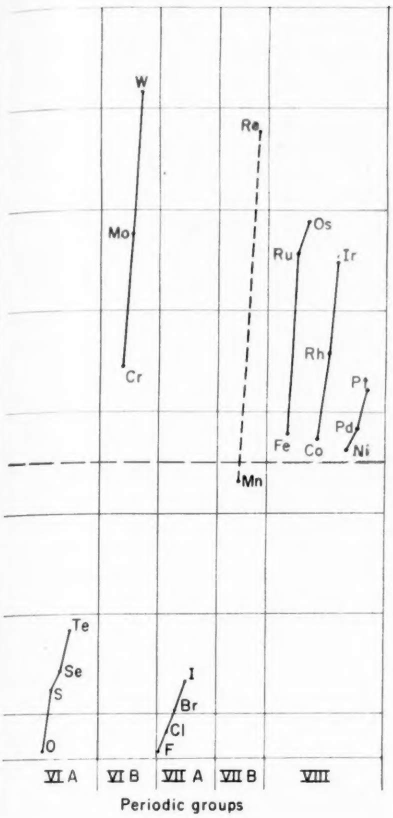
Generation of shock waves for quantitative study usually has been accomplished by a pressure-driven shock tube or by the detonation of explosives.[25] Commonly, the shock tube is a metal tube divided by a diaphragm into a low-pressure and a high-pressure section.

Driver gas is released from the high-pressure section by puncturing the diaphragm. A shock wave develops in front of the driver gas as it enters the low-pressure region at velocities up to 17 times the speed of sound. Temperatures up to 32,000 F. have been observed in this wave front.

Exploration of the nitrogen-oxygen reaction has indicated the energy requirements for the formation of nitric oxide.[27] Using these reported data for helium driver gas with the low-pressure tube at atmospheric pressure, and 100% compression efficiency, the energy to produce nitric oxide would cost about 12¢/lb. of product.

Generation of shock waves by detonation, is applicable to solids and liquids as well as gases, and is less expensive energy-wise. Possible disadvantages include higher equipment and operating costs and chemical interaction between detonation products and desired end products.

Recent studies with short-time electrical discharges at very high current densities report temperatures for microsecond periods in the order of 450,000 F. in helium and 1,000,000 F. in deuterium.[28] Apparently utilizing a combination of impulse and electrical energy, this technique and the high-intensity arc undoubtedly will be used to determine information such as the



thermal properties and atomic structure of materials.

Radiation

Recently, considerable work has been done to develop large-area sources of intense thermal radiation.[29] Radiating panels made up of many combustion-flame sources have been evaluated. Enclosed furnaces with large-area graphite-resistor irradiators have been used also.

Although research use of large-area radiation has been limited because it does not provide sufficiently high temperatures, a panel of high-output tubular quartz lamps with axial tungsten filaments has been extremely valuable to the NACA Langley Aeronautical Laboratory for the temperature testing of aircraft structures.

To study high temperatures under a variety of conditions, the recent development of solar and arc-image furnaces seems to have real promise. These furnaces focus thermal radiation from a high-temperature source into an image which heats the specimen of interest.

Since the energy is focused at the target, the target can be enclosed in a glass envelope and exposed in any type of environment. Further, since the heat comes from the image, the specimen can serve as its own crucible, with the center part being the high-temperature region and the outer portions the cooler sections. Such a solar furnace, controlled by a photocell through an electrically powered heliostat, can tract the sun to keep the focal point stationary.

Solar furnace utilizes a paraboloidal mirror to focus an image of the sun on the target specimen. This is analogous to the burning-glass technique where a lens is used to focus the energy.

Since the sun has a radiation temperature of about 10,000 F., it is theoretically possible to reach 10,000 F. on a black-body target. But design factors and certain unavoidable losses in the furnace limit temperatures in practice to the 5,400-6,750 F. range.

The arc-image furnace is quite similar to the solar furnace in that a paraboloidal mirror converts the source radiation into nearly parallel rays and a secondary paraboloidal mirror refocuses these rays onto the image. Essentially the same temperature can be achieved at the image as with the solar furnace.

A possible drawback of this type of device is its low efficiency, about 1% expressed as thermal flux at the image with respect to electrical input. Energy for the solar furnace is free, of course. On the other hand, clear weather is a prerequisite and the solar furnace cannot be used on a continuous basis.

Nuclear Reactor

Pressurized water reactors currently are operating at about 450 F. and organic-moderated reactors under development will reach 650 F. But this is far below the range of high temperature under discussion. What are the possibilities of increasing reactor operating temperatures?

Richard Graham of the AEC believes that within the next five years we shall obtain nuclear-source processing temperatures of about 3,200 F. under static conditions in advanced-design reactors. Initial target temperature for reactor development is 2,500 F.

To the usual containment-material problems are added others which include activation of process stream and diffusion of fission-product through the fuel-element walls. Development in attaining high temperature, though formidable, appears able to offer attractive returns.

Temperatures available to us today from a 45-ft.-dia. fission-weapon fireball in space are about 36,000 F.

Outlook—Materials

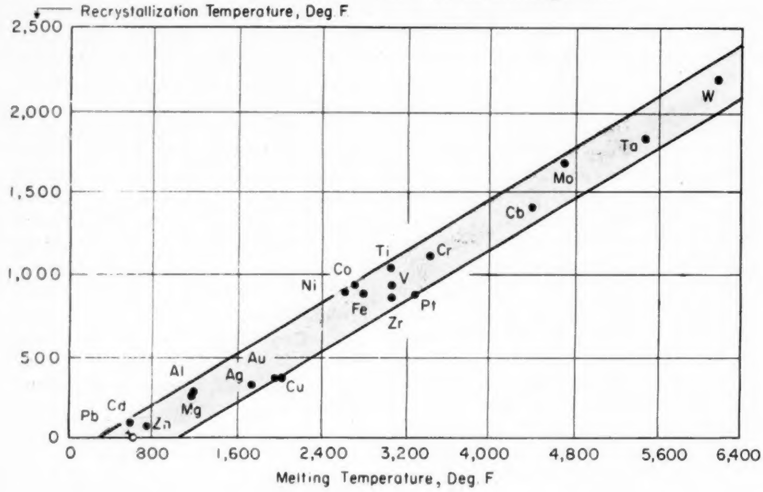
In recent years, metals engineers, metallurgists, ceramicists and chemists have engaged in extensive research to develop new materials of construction for service at very high temperatures. This search has been directed primarily toward materials adequate for the environments and stresses imposed by the gas turbine, the ram-jet engine and the rocket-propelled aircraft and missile. Such service requires that the substances be relatively inert at high temperatures and also exhibit considerable strength.

Although these properties obviously are needed for modern high-speed aircraft, the same conditions may not be needed by the chemical process industry. In certain applications, a high-temperature reactor may need to be inert only to a given chemical system at the temperatures involved and only have sufficient strength to bear slightly more than its own weight.

Even thermal shock may not be an important criteria, since care could be taken in certain continuous processes to heat up and cool down at relatively slow rates. Therefore, it would behoove the chemical engineer to review stability of high-temperature materials in various environments, reserving consideration of strength characteristics until later.

We shall try to discuss a number of known materials, regardless of their commercial availability, and even indicate some areas where new high-temperature materials might be found. Discussion will

How Recrystallization Temperature Relates to Melting Point



deal with metals and their alloys; refractory compounds such as oxides and carbides; and cermets, which are a combination of metals and their compounds.

Metals

The first consideration for any high-temperature material is that it have an elevated melting point and a relatively low vapor pressure at elevated temperature. Next, it should resist various environments such as oxidizing or reducing atmospheres, or other chemical systems. Finally, it should retain its physical strength up to temperatures as near the melting points as possible.

Before considering the high-temperature metals, it is of interest to review melting points for the entire list of elements. Melting points are plotted by periodic groups in p. 246.

Considering those elements melting above 2,500 F., it is apparent that the qualified metals are Group IVB—titanium, zirconium and hafnium; Group VB—vanadium, columbium and tantalum; Group VIB—chromium, molybdenum and tungsten; and Group VIII—iron, ruthenium, osmium, cobalt, rhodium, iridium, nickel, palladium and platinum.

Some of the Group IIIB metals, yttrium and the heavier rare earths of the lanthanide series, thorium of the actinide rare earths, and rhenium of Group VIIB also qualify as high melting. Beryllium, boron, carbon and silicon of Groups IIA, IIIA and IVA complete the list of elements melting at or above 2,500 F.

Vapor pressure data are available on some of the better-known of these metals.[31] A recomputation of these data by Sherwood,[32] Table III, shows the maximum exposure temperature for various metals so that weight loss by evaporation will not exceed 1% in 100 hr.

From a volatility viewpoint alone, chromium, zirconium, vanadium, titanium, and possibly, platinum and rhodium will become unsuitable if used at temperatures approaching 3,000 F. The low production of rhenium and hafnium and the high cost of the platinum metals may be a factor against their possible high-temperature use. This leaves niobium, molybdenum, tantalum, tungsten and their alloys as the refractory metals with the greatest potential.

Stability of metals to various environments at high temperatures has not been well studied. It is known that certain alloys containing an appreciable fraction of molybdenum exhibit catastrophic or accelerated oxidation. Possibly the reason is that molybdenum trioxide has a low melting point and thus forms a liquid oxide which volatilizes and permits additional oxidation.

Apparently, vanadium pentoxide, bismuth trioxide and lead monoxide cause similar attacks on metals. In fact, chrome-steel boiler supports have been deteriorated rapidly by vanadium pentoxide from the combustion gases of a petroleum fuel containing traces of vanadium.[33]

Work is under way to change or decrease oxidation of metals by modifying the oxide coating through alloying the metal surface with beryllium, silicon, or aluminum. Also, molybdenum has been coated with silicon to form a thin layer of molybdenum disilicide and provide satisfactory oxidation resistance up to 3,600 F. This and other coating techniques have been applied successfully to the other metals.[34]

A recent news item stated that platinum-alloy-clad aluminum was considered to be promising as a missile nose-cone material. Similar plating with other metals of the platinum group should also be satisfactory.

Another way to raise the temperature limitations of these metals is by alloying techniques. Small amounts of tungsten have improved oxidation resistance of niobium and tantalum. Chromium composition ranging from 15 to 25% in iron, nickel and cobalt base alloys imparts resistance to oxidation without reducing ductility and toughness.

Titanium and niobium alloys of molybdenum and cobalt, and niobium alloys of tungsten also have shown improved high-temperature characteristics. Tungsten alloys of this type, made at SRI, resist oxidation up to 3,000 F.; have adequate strength in inert atmospheres up to 4,000 F; and, if strength is not required, will perform satisfactorily in inert atmospheres up to 5,000 F.

Other alloying materials, such as yttrium, rhenium and ruthenium, should provide even better high-temperature properties. It may be that other members of the lanthanide rare earth series will aid in providing better high-temperature alloy systems.

Considerable work also is under way in containing liquid metals with higher-melting solid metals. Components of the higher-melting solid metals may become soluble in the hot zone of a heat transfer system, then precipitate in the cold zone with resultant plugging.

Recent work shows that additions of titanium, zirconium, chromium, nickel or aluminum reduce this effect. Apparently, a

surface compound of solid metal and additive forms which is more resistant to the liquid metal than the bare solid metal.

Another problem that becomes more pressing at higher temperatures is the interstitial solution of various gases and metals. Examples are oxygen and nitrogen in zirconium and titanium, and hydrogen in steel.

One possible solution of the problem would be to alloy the metal with another metal, such that the interstitial spaces are filled in, preventing further solution of the gases. Another method of attack is to provide an impervious coating over the metal. Coating tantalum with tin or ruthenium has eased that particular embrittlement problem.

Like most refractory materials, metals are crystalline in nature. At a given temperature, the original grain structure grows larger. These larger grains actually decrease physical strength of the metal at the higher temperatures.

The point where this growth begins is called the recrystallization temperature and, rather than the melting point, actually is the limiting factor on high-temperature strength. However, a plot shows that the two temperatures seem related in a linear manner. Thus, a high-melting material normally will retain its strength longer than a lower-melting material. This figure re-emphasizes the advantage of niobium, molybdenum, tantalum and tungsten.

Metallic Compounds

Many metallic compounds are even more refractory than the metals themselves. This is especially true of compounds formed with Groups IIIA, IVA, VA, VIA elements such as boron, aluminum, carbon, silicon, nitrogen, phosphorus, oxygen and sulfur.

Melting points for some of these compounds are shown in Table IV. Although they are predominantly the compounds based on normal oxidation states of the elements, we should point out that the oxidation states, compounds and general chemical behavior in high-temperature systems may differ greatly from those at room temperature.

It is interesting to note in Table IV that some of the most refractory materials are compounds of relatively low melting metals. Likewise, some of the more refractory metals do not necessarily form high-melting compounds. As Norton points out, the refractory properties of the compound are not decided necessarily by those of the metal, but rather by the electron bonding of the compound itself.[35]

Normally, graphite is considered in the compound class rather than with the metals because it is nonmetallic and its physical strength properties are related closely to the refractory compounds. Like alumina, magnesia and zirconia, it is in widespread commercial use.

Complex oxides in this category are mullite ($3Al_2O_3 \cdot 2SiO_2$) with a melting point of 3,326 F.; zircon ($ZrO_2 \cdot SiO_2$) with a melting point of 4,388 F.; and spinel ($MgO \cdot Al_2O_3$) with a melting point of 3,830 F.

Many other interesting oxides, such as yttria, ceria, hafnia and thoria, are not in greater use because of low availability or high cost. Chromic oxide normally is ruled out of the commercial oxides because of its high vapor pressure.

Obviously, all of the oxides are stable in oxidizing systems, except those few that change to higher forms with lower melting points. Among these are the oxides of niobium, uranium and manganese metals.

Alumina is very stable and inert to both acidic and basic slags and metals. It can be used in reducing atmospheres up to 3,450 F. and with all gases except fluorine to 3,275 F. Vanadium pentoxide is satisfactory in reducing and neutral atmospheres, and niobium dioxide in the latter.

Some of the oxides, such as those of the alkaline earths, hydrate easily although they are quite suitable for use with molten metals. Alumina, zirconia, spinel and zircon also can be used for this purpose. An example of the suitability of these and other oxides for the containment of specific molten metals is given in Table V.

One important problem in current high-temperature technology is to develop suitable crucible material for melting titanium. From this table, it is apparent that none of these refractories is satisfactory.

Brewer has suggested that Mo_3Si, TaB, ZrB_4, UB_2, CeB_4, CeS and ThS_2 might possibly be suitable as container materials although this can be determined only by actual experimental studies.[36] Laszlo has experimented with a solar furnace to find a container for melting English china clay, m.p. 3,235 F.[37]

Borides oxidize above 2,550 F. but are stable in the presence of carbon. They should find their greatest use in neutral or reducing atmospheres or vacuo.

Carbides of cerium, zirconium, niobium, tantalum, molybdenum and tungsten can be used above 3,625 F. in neutral or reducing atmospheres. Carbides of cerium, titanium, zirconium and hafnium can be used to 4,525 F. in evacuated space.

Other carbides are good also in reducing or neutral atmospheres or vacuum at somewhat lower temperatures. Generally, however, they must be kept dry, since a great number of them hydrolyze easily, especially those in Groups IIA and IIIA.

Titanium carbide, vanadium carbide and niobium carbide are especially useful in that they are stable in nitrogen to at least 4,525 F. The carbides of tantalum, mixed with those of hafnium or zirconium, are among the highest melting of the metallic compounds. Eighty percent tantalum carbide,

Evaporation Loss Is 1%/100 hr. at These Temperatures—Table III

Metal	Temp., F.	Metal	Temp., F.
Tungsten	4,640	Ruthenium	3,550
Tantalum	4,350	Rhodium	3,040
Rhenium	4,315	Platinum	2,910
Niobium	4,045	Zirconium	2,730
Osmium	3,830	Vanadium	2,625
Iridium	3,615	Titanium	2,030
Molybdenum	3,470	Chromium	1,645

Where Metallic Compounds Melt, Deg. F.—Table IV

Group	Element	Oxide	Boride	Carbide	Nitride	Silicide	Sulfide
IIA	Be	4,622		3,902	3,992		
	Mg	5,072		<			>3,632
	Ca	4,712	>3,812	4,172			
	Sr	4,379	>3,812	>3,501			>3,632
	Ba	3,483	>3,812	>3,236			>3,632
IIIA	B	<		4,442	4,946		
	Al	3,659	<	5,072	4,046		<
	Ga	3,164					<
	In	>3,600					
IIIB	Sc				4,802		
	Y	4,370					3,497
	La	4,181	>3,812				
	Ce	3,542	>3,812				3,434
	Sm						3,452
	Th	5,972	>4,532	~4,784	4,280		4,136
	U	4,136		4,307	4,766	3,092	3,362
IVA	Si	3,142		3,812		3,452	<
IVB	Ti	3,344	~4,712	5,684	5,342	2,804	3,722
	Zr	4,851	~5,423	6,386	5,396	2,768	3,812
	Hf	5,031	5,544	7,029	5,990		3,902
VB	V	3,591		5,126	3,686		3,452
	Nb	3,222	>3,632	6,332	3,686	3,587	
	Ta	3,434	>3,632	7,011	5,396	3,992	
VIB	Cr	4,109	>3,632	3,434		2,795	2,822
	Mo	<	3,956	4,874		3,686	<
	W	2,683	5,288	5,184		3,956	
VIIB	Mn	3,236		2,768			2,948
	Re	<				>3,092	
VIII	Fe	2,849	2,822	3,002			<
	Ru						
	Os						
	Co	3,281				<	<
	Rh						
	Ir						
	Ni	3,542	<			<	
	Pd					2,552	
	Pt						

Note: < denotes melting points lower than 2,500 F. Blank spaces indicate' ack of knowledge about melting point or compound.

Source: High Temperature Technology, Edited by I. E. Campbell, Wiley (1956)
Handbook of Chemistry and Physics, Chemical Rubber Publishing Co. (1947)

Schönberg to be markedly resistant to chemical reagents.[89] Their melting points, however, are in the region of 2,000 F. or less.

Graphite has become a very valuable refractory in high-temperature applications such as rocket nozzles and nozzle inserts. However, the full high-temperature capabilities of graphite have not been realized because oxidation becomes serious at relatively low temperature.

Recently, graphite characteristics have been improved by coatings of silicon carbide or other refractories, as in Norton Co.'s Rokide processes.

Another way to protect graphite, developed at SRI, consists of impregnating the graphite surface by controlled melting of metals, such as zirconium, to form zirconium carbide and free zirconium which are bound chemically rather than mechanically. Upon firing in an oxidizing atmosphere, an outer layer of refractory zirconia forms.

Major drawbacks to the metallic compounds are their relatively low ductility and poor resistance to thermal shock. This latter factor appears to be associated with a combination of low thermal conductivity and high thermal expansion.

Carbides appear best for thermal shock resistance and good mechanical strength; nitrides seem to be the most brittle. In addition, most of these compounds are difficult to fabricate because of their extreme hardness. Most present methods involve hot pressing or powder metallurgical techniques for shaping parts.

20% hafnium carbide melts at 7,120 F.; 80% tantalum carbide, 20% zirconium carbide melts at 7,130 F.

Nitrides are characterized by low resistance to oxidation. Those of Groups IIA and III hydrolyze easily to ammonia. Despite these disadvantages, the future appears promising for nitride refractories because of development of nitrides combined with other refractories.

Nitride-bonded carbides, such as the Niafrax silicon nitride-silicon carbide combination, are now available commercially. It appears likely that other combinations will appear soon.

Silicides resist oxidation exceptionally well because a glassy silica coating forms on the surface. Their main drawback is the generally low melting point of the silicon compounds.

Sulfides seem to be quite suitable for molten metals and can be used in neutral atmospheres or in vacuo. But they are easily oxidized and the Group IIA and III compounds hydrolyze rather easily. Furthermore the Group IVB sulfides also appear to carburize easily. Sulfides also have generally lower melting points.

Aluminides, such as those of molybdenum and nickel, show good resistance to thermal shock and high-temperature oxidation, but their strength is low.[88] Phosphides of the transition metals, Groups IVB to VIB have been found by

Cermets

The cermets were developed in an attempt to combine the ductility and thermal-shock resistance of metals with the high-temperature strength of ceramics. Any one or more of the ceramic materials, including the oxides, carbides, borides, nitrides, and silicides, may constitute the ceramic portion of a cermet. The metallic portion may be either a pure metal or a metallic alloy.

Cermets usually are fabricated by powder metallurgical processes to insure that each phase retains its fundamental characteristics. Although cermets are still in the development stage, commercial ap-

plication is increasing rapidly and the future use of this class of materials appears promising.

An important cermet is the 30% chromium-70% alumina combination formed by compacting the ingredients under 35,000 psi. pressure and sintering the compact at 3,100 F. in a slightly oxidizing atmosphere of hydrogen and water vapor.

On the basis of static strength tests, it was shown that the strength was not detrimentally affected by oxidation for 100 hr. at 2,750 F.; that resistance to thermal shock was marginal; and that resistance to mechanical shock was low.[39A]

A commercial development of this type of material, Haynes Metal Ceramic LT-1, contains the reverse proportions of 70% chromium and 30% alumina.

Chromium-alumina cermets show favorable high-temperature properties, but have been eliminated from the list of promising jet-engine materials because of poor thermal shock resistance.[40]

Improved thermal shock resistance has been obtained with titanium-carbide base metal-bonded cermets in developmental work sponsored both by government and industry. They appear to have promise.[41] Other cermet systems under study include combinations of chromium boride and nickel, boron carbide and iron.

Some successful commercial applications for cermets include thermocouple protection tubes for immersion in molten metal, high-temperature bearings, high pressure-high temperature reaction chambers and glass-forming dies. Development work includes adaptation of cermets to turbojet power systems, internal combustion engine valves and valve seats.

High-temperature characteristics of these materials make them attractive for uses in the intermediate range of about 1,450 to 2,700 F. However, at this time it appears doubtful that cermets will contribute anything to high-temperature technology above 2,750 F. in the foreseeable future.

Outlook—Processes

Probably the most interesting new process under development is the Sheer-Korman application of the high-intensity arc in which the reactants are contained in a consumable electrode.[43]

One experimental process operated by Light Metals Refining Corp. is designed to produce beryllium chloride by springing the 20,000-F. arc between electrodes of carbon and beryllium ore in an atmosphere of chlorine. This process can be applied to decompose metallic ores to the oxide, to produce other metallic chlorides by the use of a chlorine atmosphere, and to carbothermic reductions in an inert atmosphere.

Another adaptation springs the high-intensity arc in liquid hydrocarbon to form hydrogen and about 40% acetylene plus associated homologs.[42]

Applications of flash smelting and fluidization in high-temperature roasting and sintering are also in developmental stages. In one process, International Nickel Co. of Canada injects finely divided copper concentrates and flux into a furnace with oxygen. Combustion of the copper sulfide provides heat for the smelting process. In a similar process, Northwest Refining and Chemical Co. uses flash roasting to produce zinc oxide from the zinc-sulfide concentrates.

Fluidization also is becoming popular in the metallurgical processes. Although no fluidized processes have been reported at temperatures above 2,700 F., the technique is being adapted for processes such as reduction of zinc-ore concentrates in fluidized roasting (Cerro de Pasco Co., La Oroya, Peru), reduction of iron oxide with hydrogen (Hydrocarbon Research, Inc.), reduction of non-magnetic low-grade iron ore to magnetite for further beneficiation (Jones & Laughlin Steel Corp.), and direct chlorination of titanium by fluidization of titanium ore and coke with chlorine (E. I. Du Pont de Nemours & Co., Inc.).

Oxythermal processes that use thermal energy supplied by combustion with oxygen are being developed to replace electric furnace techniques. A German development for production of calcium carbide (Badische Anilin and Soda Fabrik) charges lime and coke to a graphite-lined shaft furnace. Combustion of oxygen with a portion of the coke provides the necessary reaction temperature.

This advance in non-electric processing may indicate the direction that high-temperature technology will turn. One such process appears to have been awaiting the advance of technology. There may be others.

A patent issued in 1925 (Brit. Pat. 259,395) claims a process whereby barium carbonate and coke react in a high-temperature flame to form barium oxide. Electrothermal decomposition of barium carbonate is an accomplished fact.

What is required to make the simpler, lower-power combustion process attractive? For one thing, commercial availability of cyanogen or carbon subnitride fuels might make the high-temperature flame more feasible for many processes which presently derive energy from the electric arc.

Considerable development effort by Battelle Memorial Institute has gone into a new high-temperature

How Molten Metals Affect Oxide Refractories—Table V

	Mo	Ni	Nb	Ti	Zr	Be	Si
Al_2O_3	A	A	A	BD	BD	BE	BE
BeO	A	A	BCE	BD	B	AB	BC
MgO	A	A	AB	BDE	D	BE	E
ThO_2	A	A	ABC	AB	AB	AB	BC
TiO_2	A	A	AC	D	D	C	..
ZrO_2	A	A	AB	BD	AB	AB	E

A. Showed no physical alteration of the metal-ceramic interface.
B. Showed penetration along the grain boundaries and alteration of the oxide phase.
C. Showed some corrosion of the oxide.
D. Showed considerable corrosion of the oxide.
E. Formed a new phase at the interface.

Source: Economos, G. and Kingery, W D ; J. Amer. Ceram Soc. 36, 12, p. 403-409 (1953)

titanium process for Kennecott Copper Co. In this process, titanium carbide is produced from rutile or ilmenite at 3,270 F.

Reaction of the carbide with iodine gas at 2,000 F. forms titanium tetraiodide. In contrast to the batch-type Kroll process for reduction of titanium tetrachloride, this thermal process continuously decomposes the purified titanium tetraiodide at low pressure and temperatures up to 3,100 F.

Though this process has not been applied commercially, there are indications that it may appear soon. Limited commercial application of a similar process by Foote Mineral Co. produces pure silicon.

Film boiling offers another interesting approach to titanium tetraiodide reduction which could find high-temperature applications. Titanium is produced on a hot tungsten filament submerged in liquid titanium tetraiodide. By maintaining proper heat input only vapor contacts the wire and deposition rates for the metal are higher than those obtained in the vapor-phase reaction.[44]

Probably the most highly publicized recent development is General Electric Co.'s production of synthetic diamonds for industrial use. This process uses temperatures over 5,000 F. and 800,000-psi. pressure.

Possibly the technique might find application in producing new high-temperature materials with considerably different properties than possessed by related materials produced at ambient pressure. Coesite is one such material that already has been made which has no counterpart in nature. It is a dense form of silica (sp.gr. 3.01) and unlike quartz is not attacked by hydrofluoric acid.

Manufacturing of materials for low-temperature processing may be considered simple while the same manufacturing technique has to strain to produce suitable material for high-temperature processing. For example, the engineer has been forced to combine various materials in an attempt to obtain desirable properties at the elevated temperatures. However, even plating of metals becomes formidable if the metals are tungsten and boron, for instance.

At Battelle Memorial Institute, I. E. Campbell and co-workers have found vapor plating to be a solution to many difficult problems.[45] By this technique, films of the desired metal are deposited by reducing their salts in proximity with the metal to be coated. The vapor deposition process can also apply coatings of carbides, nitrides, borides and silicides.

Active Future

Present-day technology is based predominantly on electrical energy for solid-solid systems or chemical energy for gas-phase reactions. Because present construction materials are limited, only a few of the latter now operate above 2,500 F.

Real gains could be realized by developing new materials to work well above this level. As the spectrum of attainable and usable temperatures broadens, information will be required about properties of new materials and compounds.

More efficient transfer of thermal energy to the reacting system is needed to lower cost. Present combustion and electric heating methods may give way to energy from high-energy particle bombardment, the nuclear reactor or a controlled hydrogen fusion reaction.

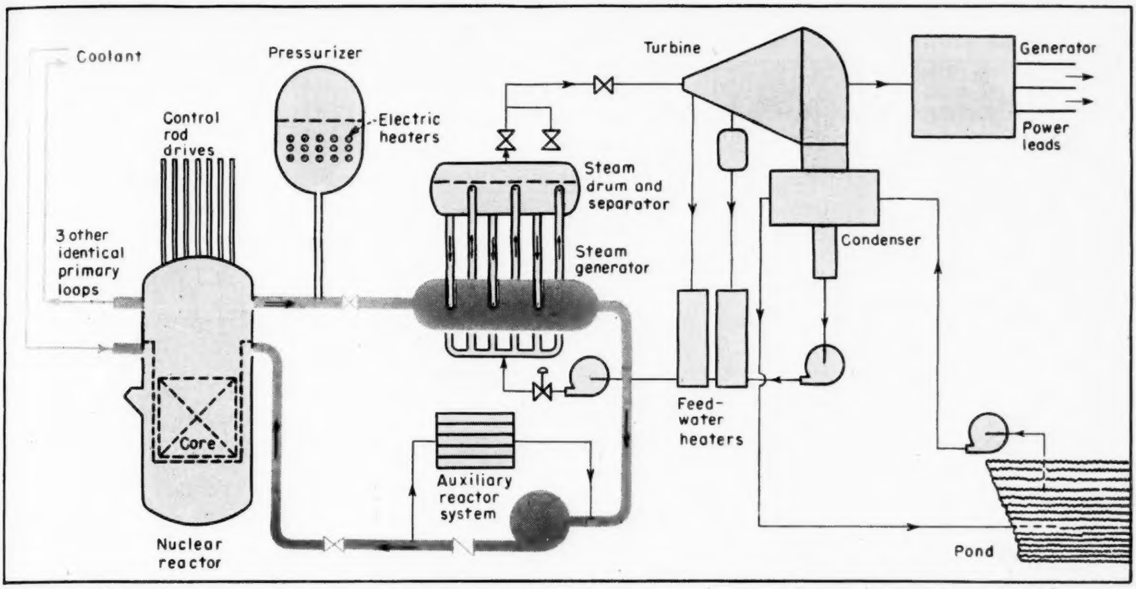
New chemical systems will be explored to bring forth new types of compounds based on nitrogen, silicon, phosphorus, boron and others rather than carbon.

Insufficient thermodynamic and kinetic knowledge at high temperature is being bolstered despite the tremendous scope of the task and lack of equipment for investigations above 3,500 F.

With the growing interest and research effort now directed at high-temperature problems, it behooves chemical companies to watch the results and how they might be applied to processes of interest.

REFERENCES

1. Kirk, Othmer, "Encyclopedia of Chemical Technology," Vol. XI, p. 632
2. Steffans, Carsten, Symposium Proceedings "High Temperature—A Tool for the Future," Stanford Research Institute (1956)
3. Wise, H., D. I. Baker, *J. Chem. Phys.* **21**, 10; p. 904-5 (1953)
4. Pring, J. N. "The Electric Furnace," Longmans, Green and Co. London (1921)
5. Kobe, K. A., "Inorganic Process Industries," The MacMillan Co. (1948)
6. Gilbert, N. and F. Daniels, *Ind. Eng. Chem.* **40**, p. 1719 (1948)
7. Ermenc, E. D. *Chem. Eng. Prog.* **52**, 4; p. 149-53 (1956)
8. "Nitrogen Symposium" Food Machinery and Chemical Corp. and Wisconsin Alumni Research Foundation, New York, Nov. 1955
9. U. S. Pats. 1,212,119; 1,233,923; 1,233,926
10. J. H. Karase, J. G. Thompson, J. Y. Yee, *Ind. Eng. Chem.* **18**, p. 1287, (1926)
11. Dungan, T. A., *Trans. A.I.M.E. Vol.* **159**, p. 308-14 (1944)
12. Byrns, A. C., *Chem. Eng. Prog.* **43**, 4; p. 172-3 (1947)
13. Mantell, C. L. "Industrial Electrochemistry," McGraw-Hill, New York (1940)
14. "Development of Processes for Production of Fused Tricalcium Phosphate," Chemical Engineering Report No. 7, 1953—Tennessee Valley Authority
15. Kelly, J.C.R., Symposium Proceedings, "High Temperature—A Tool for the Future"
16. Bixler, G. H. and C. W. Coberly, *Ind. Eng. Chem.* **45**, p. 2596 (1953)
17. Altman, David, Symposium—"High Temperature—A Tool for the Future"
18. Grosse, A. V., Symposium—"High Temperature—A Tool for the Future"
19. Stewart, P. B. and F. Kreith, *Chem. Eng.*, Sept. 1953 p. 208
20. Weisenberg, I. J. and Winternitz, P. F., "The Rocket Motor as a Chemical Reactor" (Illustrated by Nitrogen Fixation). Sixth Symposium (International) on Combustion, Combustion Institute, Pittsburgh, Pa.
21. Cobine, J. D. and D. A. Wilbur, *Electronics*, June 1951
22. McCarthy, R. L., *J. Chem. Phys.* **22**, 8; 1360 (1954)
23. MacPherson, H. G., Symposium Proceedings, "High Temperature—A Tool for the Future"
24. Sage, B. H., A. I. Ch. E. Annual Meeting, Los Angeles, Calif. Feb. 1956
25. Duvall, G. E. and M. C. Kells, Symposium Proceedings, "High Temperature—A Tool for the Future."
26. Petscheck, H. E., et al., *J. Appl. Phys.* **26**, 1; 83-95, Jan. 1955
27. Glick, H. S., W. Squire, A. Hertzberg, "A New Shock Tube Technique for the Study of High Temperature Gas Phase Reactions", Fifth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, Pa.
28. Fischer, Heinz, Symposium Proceedings, "High Temperature—A Tool for the Future"
29. McGreevy, Joseph M., Symposium Proceedings, "High Temperature—A Tool for the Future"
30. Graham, Richard H., Symposium Proceedings, "High Temperature—A Tool for the Future"
31. Dushman, S., "Vacuum Technique," John Wiley and Sons, New York, 1949
32. Sherwood, E. M., "High Temperature Technology." Edited by I. E. Campbell, John Wiley and Sons, New York, 1956
33. Cubicciotti, Jr., D. D. Symposium Proceedings, "High Temperature—A Tool for the Future"
34. Bradstreet, S. W. and I. E. Campbell, Symposium Proceedings, "High Temperature—A Tool for the Future"
35. Norton, J. T., Symposium Proceedings, "High Temperature—A Tool for the Future"
36. Brewer, L., "The Choice of the Proper Refractory for the Casting of High Melting Electropositive Metals, "University of California Radiation Laboratory Report No. UCRL 762 (1950)
37. Laszlo, T., Symposium Proceedings, "High Temperature—A Tool for the Future"
38. Richardson, L. D., Sr. "High Temperature Technology," Edited I. E. Campbell, p. 6.
39. Schönberg, N. *Octa Chem. Scand.* **8**, p. 226 (1954)
39A. Blackburn, A. R., Shelvin, T. S. and Lowers, H. R., *J. Am. Ceram. Soc.*, **34**, 327-331, Nov. 1951
40. Richardson, L. D. "Ceramics for Aircraft Propulsion Systems" Paper presented at Pacific Coast Regional Meeting of the American Ceramic Society, October 22, 1953.
41. Richardson, Sr., L. D., "High Temperature Technology" Edited by I. E. Campbell, p. 4
42. *Chemie-Ingenieur-Technik.* **28**, p. 706 (1956)
43. "The High Intensity Arc in Process Chemistry" Charles Sheer and Samuel Korman. Vitro Corporation of America
44. Peterson, A. W. "Preparation of Metallic Titanium by Film Boiling." U.C.R.L. Report No. 2523, April 1954
45. Campbell, I. E., Symposium Proceedings, "High Temperature—A Tool for the Future"
46. Margrave, John L., Symposium, Proceedings, "High Temperature—A Tool for the Future"



FROM DESIGN of nuclear reactor heat transfer systems, here is engineering and cost information to help you . . .

Select Best High-Temperature Coolant

Many factors have been evaluated in choosing high-temperature coolants for nuclear reactors—corrosion, cost. This information can help you design a better high-temperature heat transfer system.

W. E. PARKINS, Atomics International, Canoga Park, Calif.*

Selecting the proper coolant is a most important and difficult engineering problem in the design of any nuclear reactor.

Much work has been done in this field of interest to chemical engineers. Many types of heat transfer agents have been considered and evaluated.

But to better understand the problems, let's look at the requirements of a reactor coolant system. Of course the function of a reactor coolant is to remove heat generated within a reactor core. A coolant circulation system for this purpose is a necessity for any nuclear reactor operating at a high power level.

Heat, which the coolant removes from the reactor fuel in passing through the core, is given up by the coolant as it flows through an external circulation system.

This heat may be dumped to the atmosphere or some body of water, or it may be used in a thermodynamic cycle for the generation of power. The external circulation system is comprised of components such as a pump, heat exchanger, and instrumentation to measure flow, levels, pressures, and temperatures.

The system may include provision for side stream purification, for system filling and venting, for monitoring radioactivity levels, and for measuring impurity concentrations. As an additional complication, the piping and components in this coolant circulation system usually require shielding for nuclear radiation.

For a practical heat transfer system circulating a fluid, there are many well known conventional engineering factors that have to be considered: heat transfer, corrosion characteristics, cost, and the availability of commercial system components.

The nuclear reactor imposes on its coolant system additional new requirements not previously important in conventional practice. Such new requirements include neutron absorption and scattering properties, stability to radiation decomposition, and types of induced radioactivity.

These additional factors have contributed to the difficulty in selection of reactor coolant materials and in the engineering of reactor coolant systems.

High Temperatures

Air and water (including D_2O) were the first reactor coolants, choosen principally because of availability, engineering familiarity, and tolerable nuclear properties. It is interesting that today these are the only coolants seriously considered for low-temperature reactor systems. Reactors in this category are used for research and for production of special weapons materials.

* Meet your author on page 328.

As a First Approximation...

Consider Elements*as High-Temperature Coolants Table I

Element	Melting Pt. Is High	Element Is Corrosive	Absorbs Neutrons	Cost Is High	Toxic, Unstable
Li			X		
Li^7				X	
Na					
Mg	X				
Al	X	X			
P					X
S					X
K					
Zn	X	X			
Ga		X		X	
Se			X	X	
Rb				X	
Cd			X		
In			X	X	
Sn		X			
Sb	X	X			
Te	X			X	
Cs			X	X	
Ce	X			X	
Hg			X	X	
Tl				X	
Pb					
Bi					X

* All elements with mp. below 1,250 F. and b.p. above 400 F.
"X" marks disadvantage.

Many other applications for reactors now becoming important, such as generation of electrical power, propulsion of ships and aircraft and the production of industrial heat, essentially all require economic reactor coolant systems capable of operation at elevated temperatures.

This performance requirement places an entirely different aspect on the selection of the coolant material and the design of the coolant circulation system. In elevated temperature operation, engineering of the coolant system becomes an extremely difficult problem. In practice, design of any reactor is largely determined by engineering compromises made on the basis of limitations imposed by the coolant.

In addition, while there are many possible coolant materials, no practical choice is without its own special difficulties. This factor has probably been responsible in contributing to the wide variety of different reactor designs now proposed for applications requiring high temperature.

Very generally, we require that the coolant have low cost, good heat transfer characteristics, low neutron absorption, low melting point, low vapor pressure, good radiation and thermal stability, low corrosive characteristics, chemical inertness, and unobjectionable induced radioactivity.

In addition, it is important that equipment and an accompanying technology be available for handling and pumping the coolant. It is also an advantage in certain reactor designs if the coolant has good neutron moderating properties so that it may serve as both moderator and coolant. With these numerous requirements for the ideal coolant, it is a challenging problem to select the fluids which can best be utilized in high-temperature reactor designs.

Available Coolants

Let's consider the available materials as divided into the following categories: gases, water, other inorganic compounds, organic compounds, liquid metals.

At the present time, materials in each of these categories are under serious consideration for use in high temperature reactors, with the exception of inorganic compounds other than water. Examples of these latter compounds which have been mentioned as reactor coolant possibilities include the NaOH-KOH eutectic and the $NaNO_2$-$NaNO_3$-KNO_3 high-temperature salt. While these compounds are not liquid at room temperature, they can be melted and circulated at slightly higher temperatures.

Compared to other available coolants, however, they are not being seriously considered because of important disadvantages: (1) relatively high neutron absorption cross sections, (2) susceptibility to radiation decomposition, (3) severely corrosive characteristics.

Gases as Coolants

In general, the great disadvantage of gases as coolants is poor heat transfer characteristics. Low heat transfer coefficients obtained with gases and their low volumetric specific heats inevitably lead to relatively low specific power for the reactor fuel and relatively high pumping costs for the circulation of the coolant.

Air has been used as a reactor coolant and is considered for future applications—particularly where an open cycle (passing air directly through the reactor and exhausting to the atmosphere) is desirable. Other disadvantages characteristic of air are: An appreciable neutron absorption cross section due to the presence of nitrogen; an objectionable induced radioactivity in the form of A^{41} from the neutron absorption in the argon and N^{16} from the (n,p) reaction on O^{16}; certain corrosive characteristics due to oxygen.

To a certain extent the disadvantages of radioactivity produced and the corrosive characteristics of air can be removed—at the expense of a somewhat more costly coolant—by the use of nitrogen. In this case only a closed cycle is practical.

For the closed cycle application another gas, carbon dioxide, has been more favorably considered, and is presently used in the gas-cooled reactor program in England and France.

Carbon dioxide can produce corrosion if used at high temperatures. Such corrosion may also be accelerated by the presence of radiation which produces some decomposition of CO_2. However it is an inexpensive gas, and its low neutron absorption cross section is highly desirable.

In the United States helium is the gas most favored for a closed cycle reactor coolant. It requires the least pumping power of the gases mentioned. The neutron absorption, induced radioactivity and corrosive properties are perfect for a reactor coolant. But it's more difficult to contain within a system operating at elevated temperature

with mechanical shaft seals on rotating equipment. Another disadvantage is the high cost of the coolant itself.

Water as Coolant

Ordinary light water has a wide application as a reactor coolant. It's used for low-temperature research reactors and low-temperature production reactors. And also in high-temperature reactors such as the pressurized water units for submarine propulsion and for electrical power production.

Ordinary water has the advantage of acting as a moderator as well as coolant and permits a compact core design. Radioactivity produced in the water itself is minor.

Other important advantages are low cost, and availability of commercial equipment for the circulation system components.

At the same time, water has several serious disadvantages when used at elevated temperatures. Its vapor pressure requires a pressurized system and the small temperature excursion desirable in any practical design leads to relatively high pumping power requirements. Another serious limitation is that of corrosion, in part aggravated by the radiation decomposition of the water.

Designs have also been considered for the use of heavy water as a high-temperature reactor coolant. All such arrangements have simultaneously considered heavy water for the moderator as well, since this is one of the principal advantages of D_2O. And the combination as coolant and moderator permits simplicity of design. The only real advantages of heavy water over light water result from its special nuclear properties. These, of course, are available only at a significant increase in the cost of supplying and maintaining the coolant.

Organics as Coolants

The disadvantages of the pressurized system and the corrosive characteristics of water can be offset by the use of organic fluids.

Certain organics have sufficiently low vapor pressure to permit operation at relatively high temperatures without the expense and complication of a heavy pressure vessel. The temperature in all cases is limited eventually by the thermal stability of the organic compound.

Radiation decomposition plays a more important role, requiring coolant purification and makeup to prevent an excessive increase in the concentration of decomposition products.

Another disadvantage of organic fluids is poor heat transfer properties. Heat transfer coefficients are usually low, and pumping power requirements may be high, depending on the viscosity under the conditions of operation.

Some of the organic liquids investigated as possible coolants include benzene, diphenyl, the various terphenyls, triphenyl methane, and phenanthrene.

This choice can be narrowed further because benzene, while perhaps the most radiation stable of organic compounds, has a low boiling point of 176 F. Triphenyl methane and phenanthrene have high boiling points of 679 F. and 644 F. respectively, but represent more complicated compounds subject to radiation decomposition and somewhat expensive as far as the makeup requirements.

Diphenyl and terphenyl are compounds now planned for use in reactor units for ship propulsion and for power generation. Diphenyl boils at 488 F. and requires some system pressurization at most operating temperatures of interest. It also melts at 156 F. and requires provision for system heating prior to operation. This latter requirement can be removed by the use of the more expensive isopropyl diphenyl which melts at −22 F.

Another serious contender is a commercial mixture of the terphenyls known as Santowax R. This material melts in the range from 145 F. to 293 F. and has a vapor pressure similar to its major constituent, metaterphenyl. Since the boiling point of metaterphenyl is 689 F. the system pressure can be significantly lower than that of diphenyl.

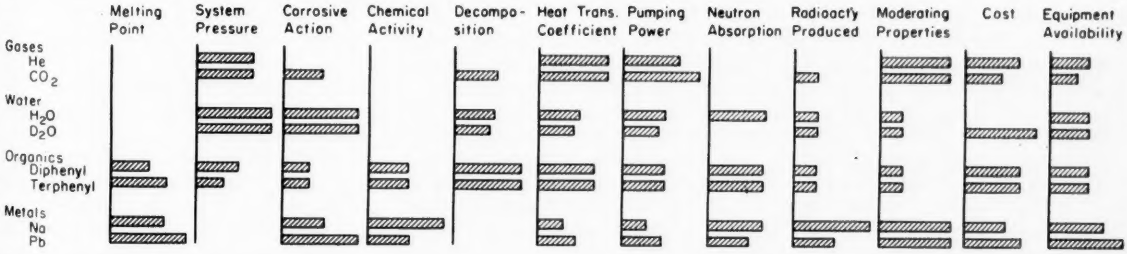
The terphenyls and diphenyl have other properties, important in reactor coolant application, which are similar to those of water. They are considered for use as both moderator and coolant in practical designs, and commercial equipment is available for the construction of circulation systems. Such equipment has been developed for hot process installations in the petroleum industry. The nuclear properties of these organics are similar to those of ordinary water.

Liquid Metals as Coolants

In the selection of a coolant for high temperature reactor operation, liquid metals have obvious possibilities. They have low vapor pressures, good heat transfer properties and complete absence of radiation or thermal decomposition.

The problem of choosing an optimum liquid metal coolant is diffi-

For Comparing High-Temperature Coolants, Consider These Factors* – Table II



*Shaded area indicates relative disadvantage.

cult, however, because of the wide range of physical and chemical properties which the various liquid metals exhibit.

An approach to this problem of selection is indicated in Table I, in which all elements with melting points below 1,250 F. and boiling points above 400 F., where known, are listed. Some of the elements listed are not true metals, but are included since they could serve as reactor coolant not dependent upon chemical combination. Also, a special case is included for the separated isotope, Li^7. The separation of the preponderance of Li^6 from Li^7 is one of the simpler applications of isotope separation techniques, and the pure Li^7 has a sufficiently low neutron absorption so it can be considered as a reactor coolant.

In Table I selection is indicated primarily on melting point, corrosive characteristics, neutron absorption cross section, and cost of the coolant. An "X" denotes one of these properties which is considered excessively high to permit practical application of the coolant in a high temperature reactor system.

Three elements, Na, K, and Pb, have properties which do not limit their practical application as coolants. All other elements listed have one or more difficulties which, on the basis of the evaluation, are eliminated from consideration. Three elements, P, S, and Bi, have special difficulties other than the four properties mentioned above.

At the present time phosphorus is considered unusable due to gradual formation of stable red phosphorus from the white allotropic form. This red phosphorus would remain a solid and impair the operation of the coolant system.

Sulfur is eliminated as a practical coolant because of a combination of heat transfer properties. Over a considerable temperature range, viscosity of sulfur is so high that even for appreciable flow velocities, a laminar flow condition would exist. This condition, together with the low thermal conductivity of sulfur, results in an unusable heat transfer coefficient.

Bismuth has a major difficulty: production of Po^{210}, an alpha particle emitter with a 138-day half-life. This isotope presents a tremendous physiological hazard because of the extremely low body tolerance and its ability to migrate around within any accessible volume. Until more experience is obtained, perhaps with auxiliary equipment making possible the continuous removal of Po formed, liquid bismuth appears to be an impractical coolant for reactor plants.

Alloy Coolants

In addition to the elements listed in Table I there are certain alloys which deserve consideration as possible high temperature reactor coolants. The number of alloys available is much larger than the number of elements, but in almost all cases, there are more disadvantages than advantages in dealing with an alloy.

The principal advantage gained by alloying is the possibility of a lower melting temperature than with any of the constituents alone. Except for such an improved melting point, an alloy is likely to exhibit the disadvantages of all the constituents. A few binary alloys do appear attractive as coolants but none of the ternary or higher order alloys have superior advantages.

An alloy of Na and K has received serious attention as a reactor coolant and has been successfully used in the EBR-I installation. The only advantage of this NaK alloy over Na is the lower melting point, making the alloy a liquid at room temperature conditions. In all other respects NaK exhibits slightly poorer properties from the standpoint of a coolant.

Similarly it is possible to alloy the element Pb to lower its objectionably high melting point of 621 F. Several elements, in particular Bi, Sn and Mg, have been suggested as alloying agents. Bismuth is presently unsatisfactory due to the production of polonium.

Of the various elements and alloys which have been considered, Na is receiving the most attention for reactor designs. It is being used in the SIR and is planned for use in the SRE, the EBR-II and in full-scale plants being planned by the Consumers Public Power District of Nebraska and the Atomic Power Development Associates.

Sodium has a reasonably low melting point, satisfactory properties from a corrosion standpoint, good heat transfer characteristics, low cost, and a tolerable neutron absorption cross section. Its most significant disadvantages are the Na^{24} (an energetic gamma emitter with a 15-hour half-life) formed and its chemical activity, which requires the sodium be excluded from contact with the atmosphere.

No Perfect Answer

Each coolant type has its own special difficulties. It is the problem of the reactor designer to select the least objectionable coolant for a reactor being designed for a specific application. He must develop an over-all design configuration of the core, the primary coolant circulation system, the shielding, and the various auxiliary systems, which will meet the reactor performance requirements within the limitations imposed by the particular properties of this coolant.

Table II gives a list of twelve of the most significant points of consideration (in the form of difficulties) associated with the use of reactor coolants.

As a qualitative indication of where these difficulties are important for the four categories of coolants, a bar is shown opposite each difficulty listed in the column representing each coolant. To be representative of some of the most promising coolants in each category, He and CO_2 are included as gases, H_2O and D_2O as water, diphenyl and terphenyl as organics, and Na and Pb as metals. Such a chart cannot be used in selecting the over-all optimum coolant because of "weighting factors" which must be considered in connection with any particular reactor design.

A glance at Table II might indicate that helium is the most desirable coolant since no difficulty is involved in so many of the points of consideration.

As a practical matter, the very serious disadvantage of the poor heat transfer properties of helium, or any other gas, are such as to encourage the use of liquids as reactor coolants. Water, in the form of either ordinary or heavy water, has many advantages. Among its disadvantages, however, is the requirement of a high system pressure for operation of the coolant at elevated temperatures. This is such an important design consideration as to strongly suggest use of lower vapor pressure materials such as the organics or liquid metals.

Topics and Organization of this CE Reference Series

Section I
Tanks
Reactor design
Mixers and agitators
Materials handling
In This Issue

Section II
Piping
- Fluid flow
- Pipe, hose, tubing
- Valves, traps, special fittings
- Fabrication and installation
- Piping identification
- Pipe supports and thermal stress

Section III
Pumps and pumping
Water supply and treatment
Electrical power

Section IV
Compressors
Jet ejectors and eductors
Design and cost estimating

Section V
Heating
Ventilating and air conditioning
Insulation
Power transmission

Section VI
Heat transfer
Heat exchangers
Chemical engineering
Kinetics

Section VII
Materials of construction
Corrosion
Paints and coatings
Physical data

Section VIII
Separation processes
Distillation, evaporation
Absorption
Drying
Air pollution
Dust collectors
Entrainment separators

Section IX
Instrumentation
Refrigeration
Structural engineering
Illumination

Your Design Reference File—I

From the author's working files, a critical selection of references with comment on content, arranged to save you time in design work

RALPH CUSHING, Senior Process Engineer, Mobay Chemical Co., St. Louis, Mo.*

Many engineers in the chemical process industries frequently perform work outside of their speciality field. A chemical engineer with a small or moderately sized company may find that he has to perform work in heating and ventilating, electrical, structural or corrosion fields. Often the kind of information that he needs is not readily available in the customary reference books. Therefore, considerable time is required to obtain the necessary information. Additional time is also required to perform the necessary calculations.

The author spent four years of his career in a position where he frequently performed work in fields other than his own speciality. It was during this period that he collected an extensive file of articles to aid him in his work.

In the spring of 1956, Cushing taught a course in plant design at Syracuse University. A selection of articles from his files was used by him in presenting the fundamentals of plant design to the students taking the course.

The result of the author's interest in building a file of engineering articles is the present series. The articles have been abstracted from 14 periodicals. Some over-lapping of material is unavoidable. Only those articles valuable in design, maintenance, trouble shooting and installation work are included. Another limitation is that an article should be included only if it adds data not given elsewhere under the same topic heading. Manufacturer's bulletins are included where they contained information not available from the literature.

The major part of the material presented is from the published literature of the last five years. In some cases, articles of outstanding merit more than five years old are included—especially where more recent articles are not available. The most recent article is listed first under each topic heading, followed by the earlier ones.

The usefulnes of articles from the literature depends on their accessibility. A simple and usable method of filing has been described by the author in **"Filing of Articles,"** *Heating, Piping & Air Conditioning*, July 1956.

Each month, we will publish the author's selection of articles under the headings listed in the box. In this series you will find references to many articles that will be helpful in your work. Use of this published information will aid you to accomplish a given task with optimum effort for a desired degree of accuracy.

THE EDITORS

*Meet your author on p. 326.

Tanks

Codes, Wall Thicknesses, Vessel Weights

"Determine Vessel Weights Graphically," H. J. DeLamater, *Pet. Refiner*, July 1955, pp. 157-160.
A new chart solution for the weight of vessels and accessories is presented. Nomogram for weights of tray supports, downflow plates and insulation rings.

"Metal Thickness of Steel Tanks," T. W. Reynolds, *Heating and Ventilating*, Dec. 1953, pp. 84-87.
An assembly of formulas and data to determine the thickness of steel tanks used to store liquids.

"Unfired Pressure Vessels," Alloy Fabricators, Résumé No. 1, Section VIII, 1952.
Summary of scope and design conditions for 1952 ASME code for unfired pressure vessels.

"Formulas and Computations for the Design of Unfired Pressure Vessels," Alloy Fabricators, Résumé No. 2, Section VIII, 1952.
Summary of formulas and computations for internal pressure.

"Unfired Pressure Vessels Subject to External (Collapsing) Pressure," Alloy Fabricators, Résumé No. 3, Section VIII, 1952.
Summary of calculations and formulas for (external pressure) vacuum source.

"A Condensed Tabulation of the 1952 ASME Code," Alloy Fabricators, Résumé 4, Section VIII, 1952.
Tabular form.

Capacity and Sizing

"Tank Capacity Diagram for Approximate Values," Engineering Data Sheet No. 5, *Pet. Processing*, May, 1956, pp. 141-142.
Nomographic and tabular forms used.

"Estimating Tank Capacity," Bruce Fader, *Chem. Processing*, Jan. 1956, p. 166.
A nomographic solution and a graphical solution for vessel capacities.

"Sizing Horizontal Tanks," Robert Hlavin, *Chem. Processing*, May 1953, p. 42.
Nomographic form.

"Nomograph for Determination of Capacity and Contents of Horizontal Cylindrical Tanks," *Industry & Power*, Oct. 1949, p. 101.
Nomographic form.

"Volume Contained in a Cylindrical Tank," *Chem. Ind.*, Aug. 1945, p. 306.
Height, diameter vs. cubic feet, nomographic.

Design

"Help in Designing Pressure Vessels," R. W. Schneider, *Chem. Eng.*, Feb. 1956, pp. 171-174.
A rapid graphical method of estimating maximum stresses in vessels with flat heads. Method is accurate enough to use minimum safety factors.

"Charts for Pressure Vessel Design," C. J. Major, *Chem. Eng.*, Apr. 1955, pp. 172-175.
Four new nomographs offer a quick way of getting shell or head thickness for cylindrical and spherical pressure vessels. Based on 1952 Code.

"Save Time in Vacuum Vessel Design," J. A. Hunter, *Pet. Refiner*, Feb. 1955, pp. 100-102.
A new direct reading chart for designing vacuum vessels is presented and discussed.

"Calculation Sheets for Vessel Design," J. G. Nelson, *Pet. Refiner*, Nov. 1948, pp. 85-92.
Standard forms for vessel design calculations, very thorough and concise. Considers thickness, wind loading, base design, anchor bolts, vessel design; detailed calculations and formulas with examples.

"Strength Against Buckling—Design of Thin-Walled Towers," Harold E. Lonngren, *Pet. Refiner*, Nov. 1948, pp. 106-107.
Graphical solution of a readily comprehensible formula for calculating maximum allowable height.

"These Short-Cuts Will Speed Your Design and Estimation of Tanks," E. H. Coe, *Chem. Eng.*, Sept. 1948, pp. 107-109.
Six charts for the design and cost estimation of tanks up to 1,000 gal. capacity.

"How to Size Future Process Vessels," A. H. Younger, *Chem. Eng.*, May 1955, pp. 201-202.
Design of vapor-liquid separators, accumulators and knock-out drums; cost vs. dimensions.

"Flash Tank Design," T. W. Reynolds, *Air Cond., Heating & Ventilating*, Apr. 1955, pp. 96-97.
How to select a flash tank for a given service.

"Practical Piping Problems," Robert C. Soronen, *Heat., Piping & Air Cond.*, Feb. 1950, pp. 98-100.
Flash tanks for high pressure condensate; blow off tanks and piping; dimensions vs. capacity for flashing.

"Design Points You Need to Build a Blow-Off Tank," Stanley H. Sye, *Power*, Jan. 1949, pp. 86-87.
Step by step procedure for laying out an adequately-sized boiler blow-off tank. Illustrative example.

"Short Cut to Air Receiver Design," J. T. Fong, *Pet. Refiner*, Apr. 1955, pp. 165-167.
Graphical method for design of air receivers.

"How to Protect Your Pressure Vessels," C. G. Weber, *Chem. Eng.*, Oct. 1955, pp. 170-174.
Practical information on what devices are available and the best way to use them. How to select safety devices; combination devices; construction features, installation; maintenance and inspection.

"How to Select and Apply Safety Heads for Protection of Pressure Systems," J. F. Myers, *Power*, Feb. 1955, pp. 101-103.
Selection of correct rupture disk; code requirements; effects of pressure and temperature; typical arrangements; selection factors; relieving capacity for prebulged safety heads of given diameters on pressure vessels.

"Design Closed Vessels to Withstand Internal Explosions," E. W. Cousins and P. E. Cotton, *Chem. Eng.*, Aug. 1951, pp. 133-138.
Results of tests of rupture disks in explosions in various sizes and strengths of vessels for various gases and vapors. Open vent reduces explosion pressures; pressure build up prior to rupture; explosion pressure vs. initial pressure; vent ratio reduction of explosion pressures; initial pressure vs. rate of pressure rise; rupture disk materials of construction. Designing closed vessels for containing explosive gases.

"Flange Design Calculations," Harold E. Lonngren, *Pet. Refiner*, Nov. 1947, pp. 130-134.
New formulas are presented for determining flange thickness with an assurance of obtaining predetermined and uniform stress distribution in the flange.

Materials of Construction

"New Alloys For Multi-Layer Vessels," G. E. Fratcher, *Pet. Refiner*, Nov. 1954, pp. 137-141.
Techniques of construction, development of high-yield strength, low-alloy plate steel, fabrication of a vessel from this steel, and test of the vessel is reported; closure design; service applications.

"Determining Allowable Stresses," W. P. Kerkoff, *Pet. Refiner*, Nov. 1954, pp. 142-147.
A summary of American and European practices, along with a proposed new method.

"A Look Ahead In Vessel Design," E. W. Jacobsen, *Pet. Refiner*, Nov. 1954, pp. 148-155.
Low-pressure design problem; hydrogen attack; brittle fracture; high-pressure design problems; selection of materials; laminated vessels; creep.

"Everdur Metal For Tanks and Equipment," The American Brass Company, *Publication E-13*, 1954.
Physical properties; design factors; welding methods.

"Aluminum Tanks and Pressure Vessels," E. V. Sharpnack, Sr., *Prod. Eng.*, Apr. 1953, pp. 183-185.
Dimensions, capacity, operating pressures, weights.

Reactor Design

General

"Electronic Analogs In Reactor Design," J. A. Beutler and J. B. Roberts, *Chem. Eng. Progress*, Feb. 1956, pp. 69-F—74-F.
Applications in kinetics studies; sequential reactions; non-isothermal reaction; unsteady state reactions; advantages and limitations of operational analog.

"Charts Simplify Job Of Designing Your Reactor System," T. M. Jenny, *Chem. Eng.*, Dec. 1955, pp. 198-202.
Nine charts which simplify the tedious calculations involved in designing the best chemical reactor system; theory and method of graph construction.

"Continuous-Flow Reactors," Thomas K. Sherwood, *Chem. Eng. Progress*, July 1955, pp. 303-304.
The problem of variable residence times discussed from a theoretical and practical viewpoint.

"How To Determine Economical Batch Sizes," S. E. Andersen, *Chem. & Met. Eng.*, July 1946, p. 237.
The determination of the optimum batch size, solved by reference to the relative costs of change over and of holding materials in inventory.

Simple Reactors

"Chemical Engineering Fundamentals—Why Kinetics For Reactor Design?," T. E. Corrigan and E. F. Young, *Chem. Eng.*, Aug. 1955, pp. 199-200.
Introductory; mechanisms affecting reactor design.

"Chemical Engineering Fundamentals—General Considerations In Reactor Design, Parts I-III," T. E. Corrigan and E. F. Young, *Chem. Eng.*, Sept.-Nov. 1955.

Part I, Sept. 1955, pp. 203-206.
Process breakdown; classification of chemical reactors; factors in selection and sizing of reactors; type of reaction; methods of operation.

Part II, Oct. 1955, pp. 211-214.
Simple reactions; effect of temperature; effect of pressure on first and second order reactions; effect of backmixing; flow reactors.

Part III, Nov. 1955, pp. 217-220.
Backmixing vs. longitudinal flow reactors; the effect of backmixing on various order reactions; reactant ratio; effect on volume at same conversion.

"Chemical Engineering Fundamentals—Reactor Design Problem: Simple Reaction," T. E. Corrigan and E. F. Young, *Chem. Eng.*, Dec. 1955, pp. 211-214.
Backmixing and conversion at constant volume; backmixing in reactor selection; approach to the design problem; a sample problem solved; cost calculations.

Complex Reactor Design

"Chemical Engineering Fundamentals—Reactor Designs For Complex Reactions, Parts I-II," T. E. Corrigan and E. F. Young, *Chem. Eng.*, Jan.-Feb. 1956.

Part I, Jan. 1956, pp. 207-212.
Parallel reactions; effects of temperature, pressure, catalyst, recycling product, backmixing; effects of backmixing on overall rates, distribution; longitudinal vs. backmixing reactors; series reactions; equation for product distribution.

Part II, Feb. 1956, pp. 193-196.
Added reactants; effect of reactant ratio; product distribution equations; derivations for product distribution; distribution in longitudinal reactors; backmixing; mol ratio vs. yields.

"Chemical Engineering Fundamentals—Reactor Design Problem: Complex Reactions," T. E. Corrigan and E. F. Young, *Chem. Eng.*, Mar. 1956, pp. 201-206.
Approach to the problem; kinetic analysis; rate ratio constants; sample problem discussed and carried through step by step.

Catalytic Reactor Design

"Chemical Engineering Fundamentals—Reactor Design For Catalytic Reactions, Parts I-II," T. E. Corrigan and W. C. Mills, *Chem. Eng.*, Apr.-May 1956.

Part I, Apr. 1956, pp. 197-202.
Selection and sizing catalytic reactors; fixed bed reaction; longitudinal vs. backmixing; fluidization; longitudinal fluidized reactors.

Part II, May 1956, pp. 203-206.
Fluid flow and distribution problems in the design of catalytic reactors; presure drop vs. velocity; orifices as operational stabilizers.

"Chemical Engineering Fundamentals—Reactor Design Problem: Stable Operation," T. E. Corrigan and W. C. Mills, *Chem. Eng.*, June 1956, pp. 253-431.
Design problem in detail, step by step with applicable charts presented.

Mixers and Agitators

Selection

"The Turbine As A Mixing Tool," E. J. Lyons and N. H. Parker, *Chem. Eng. Progress*, Dec. 1954, pp. 629-632.
General approach to mixing; excellent selection chart giving range, criteria, shape relationships for various types of agitators in a variety of services.

"Mixing, The Universal Operation," Charles S. Quillen, *Chem. Eng.*, June 1954, pp. 177-224.
Theory for fluids, solids; power consumption; range of operation of mixers based on viscosity; air agitation; gas-liquid mixing; jet agitation; paddle mixers; propellers; performance curves for water-jet pump; turbines; nomograph for power consumption of turbines for turbulent and viscous flow; disk and cone impellers; paste mixing; colloid mills; plastics mixers; conical, ribbon, screw mixers; continuous mixers for liquids; pipeline mixers.

"Why Not Use Draft Tubes," A. P. Weber, *Chem. Eng.*, Oct. 1953, pp. 183-187.
Use of draft tubes for continuous type mixing vessels; mixing and heat transfer, gas liquid mixing, mixing with attrition, crutching; design limitations.

"Mixing of Liquids in Chemical Processing," J. Henry Rushton, *Ind. & Eng. Chem.*, Dec. 1952, pp. 2931-2936.
Fluid motion and mixing; blending of liquids and mixing of gases; similitude; performance characteristics of mixing impellers; scale up; heat and mass transfer; displacement capacities and velocities; process applications formulas and charts applied.

"Practical Mixer Technology," Emerson Lyons, *Chem. Eng. Progress*, May 1948, pp. 341-346.
Basic design considerations; circulation patterns; methods of baffling; limits of agitator types in different mixing jobs; estimation of mixing requirements and mechanical design.

"The Economics of Agitator Selection," E. S. Bissell, *Chem. Ind.*, Apr. 1948, pp. 586-588.
Economics and selection based on the following considerations; materials of construction; type of stuffing box; mixer size; power and maintenance requirements; multiple installation vs. single large installation; comparison of integral vs. separate stuffing box.

"Simplified Approach to Mixing Problems," H. E. Serner, *Chem. Eng.*, Jan. 1948, p. 127.
Charts to correlate; power vs. peripheral velocities at various viscosities and intensities of agitation; peripheral velocities vs. velocity through agitator; vessel specification; effect of coils on agitation.

"Development of Pfaudler Agitation," O. W. Green, Pfaudler Co. Reprint No. 508, Sept. 1953.
Principles of Pfaudler agitators; charts for determination of desired agitative level, type of agitator and rpm., required horsepower. Curves can also be used to check out existing agitators for new applications.

Design

"Effective Radius of Agitation in Viscous Liquid Mixing," H. E. Serner, *Chem. Eng.*, Apr. 1950, pp. 128-129.
Agitation patterns; consideration of the influence of the effective radius of agitation on the agitation of viscous liquids, data presented in formula and in graphical form.

"Effect of Baffles on Agitator Power Consumption," Darrell E. Mack and A. Edgar Kroll, *Chem. Eng. Progress*, Mar. 1948, pp. 189-194.
Data presented in tabular and graphical form to show effect on power consumption of baffle size; baffle position; impeller shape and size, impeller position; number of impellers; number of baffles; liquid depth; tank diameter.

"Design and Utilization of Internal Fittings for Mixing Vessels," Bissell, Heese, Everett, and Rushton, *Chem. Eng. Progress*, Dec. 1947, pp. 649-658.
Effects on design considerations of the following: location and utilization of coils, baffles, draft tubes, steady bearings, brackets compartmentation, spargers, feed pipes, thermowells, power consumption; off centered and side entering agitation.

"Performance and Design of Agitators," D. E. Mack and V. W. Uhl, *Chem. Eng.*, Sept. 1947, pp. 199-121, 125.
Agitator power requirements; gas liquid contacting equipment; examples illustrate how to design systems with or without pilot plant data, and how to predict performance of existing equipment under changed conditions.

"Power Absorption in Mixers," Richard B. Olney and George J. Carlson, *Chem. Eng. Progress*, Sept. 1947, pp. 473-480.
Nomograph for determining net power requirements of mixers; experimental data in graphical and tabular form; power data for disperser and spiral turbine impellers in several single liquids and two-phase immiscible liquid systems. Correlation of this data with power studies for other types of agitators.

Materials Handling

Selection

"Solids Feeders," Theodore R. Olive, *Chem. Eng.*, Nov. 1952, pp. 163-178.
Selection; application; design; volumetric, gravimetric and slurry feeders; operational problems; bins and dischargers.

"Evaluating Materials Handling Layouts," Wilbur G. Hudson, *Chem. Eng.*, Aug. 1947, pp. 110-112.
Case histories, examined and analysed; different ways in which solids may be handled; operational difficulties, cause and cure.

Conveyors

"Charts for Quick Selection of Belt Conveyor Shafts," John Emerson, *Flow*, Feb. 1956.
Headshaft and tail shaft selection; examples given.

"Woven Wire Belts," J. F. Reid, *Chem. Eng.*, Jan. 1956, pp. 195-198.
Weaves; Specifications; costs; materials handled; application.

"Conveyers and Elevators," Harry L. Strube, *Chem. Eng.*, Apr. 1954, pp. 195-210.
Describes the salient features of various common types of equipment for handling bulk materials continuously; provides aids for selection of the proper type of equipment for a given continuous bulk handling job; belt speeds and capacities for various weights of materials and widths of belts; normal and maximul lump size, idler spacing for belt conveyors; critical factors for materials to be handled by troughing belt conveyors; capacity charts for screw conveyors selection; Characteristics of bulk materials.

"Capacities of Large Belt Conveyors," Data furnished by Jeffrey Manufacturing Co.; nomograph prepared by *Chem. Processing* staff, *Chem. Processing*, July 1953, p. 49.
Nomograph.

"How To Splice Rubber Conveyor Belts," A. F. Matheis, *Factory Management & Maintenance*, Sept. 1953, pp. 160-164.
Types of splices; preliminary steps for slicing; vulcanized splice; metal fasteners.

"Rubber Conveyor Belting," Data prepared by Edward C. Gregory and Eugene R. Traxler, *Flow*, Mar. 1952, pp. 64-67; 84, 86, 88, 90-91.
Construction details, types of belting; selecting the right type; how to determine specifications; example; minimum pulley diameters; weight of moving parts; drive factors; permissible working stresses.

"Flight and Apron Conveyors," Wilbur G. Hudson, *Industry & Power*, Oct. 1951, pp. 109-110.
Selection factors; power determinations; fraction coefficients on steel plates; drag of materials against side plates; capacity and size of lumps handled by flight conveyors; capacities of horizontal apron conveyors and feeders at 20fpm.

Pneumatic Conveying

"Fluidization Velocities," J. Lowenstein, *Chem. Eng.*, Apr. 1955, pp. 189-190.
Graphical and nomographic determination of Fronde number or velocity.

"Why Use Pneumatic Conveyors?" Wilbur G. Hudson, *Chem. Eng.*, Apr. 1954, pp. 191-194.
Conveyor calculations; list of industrial materials suitable for pneumatic handling; velocities in fps. in pneumatic conveying; pressure losses for air and materials.

Vibration Conveying

"Handling by Vibration," *Flow*, Nov. 1955, pp. 70-73, 156-163.
Designed; construction; application, types of materials handled; selection; capacities; illustrated.

Hoppers

"Design A Hopper That Won't Arch," Julian C. Smith, *Chem. Eng.*, Sept. 1955, pp. 167-168.
Design equations; applications.

"Sizing Hoppers," Robert W. Ruppert, *Chem. Processing*, Mar. 1955, p. 192.
Nomographic Form.

"Don't Be Fooled by an Irregular Hopper," Chesman A. Lee, *Chem. Eng.*, May 1954, p. 218.
A procedure for calculating volume of irregular hoppers.

"Better Design for Bulk Handling," Andrew W. Jenike, *Chem. Eng.*, Dec. 1954, pp. 175-180.
Mechanics of flow; static pressure; impact pressure; vibrational pressure; flow-factors; flow formulas.

"Hoppers by Calculation," Chesman A. Lee, *Chem. Eng.*, Dec. 1954, pp. 181.
Application of the experimental data presented in the article by A. W. Jenike, *Chem. Eng.*, Dec. 1954.

"Design of Hoppers for Use," Chesman A. Lee, *Chem. Eng.*, May 1953, pp. 194-195, 200.
General theory of arching; causes; designing to prevent hangup; non-granular materials.

"New Ideas About Hoppers," Chesman A. Lee, *Chem. Eng.*, Apr. 1952, pp. 153, 173, 194-195, 200.
A new basis for hopper design eliminating straight sides.

GAS-LIQUID CONTACTING IN RANDOM-PACKED TOWERS

Flow Through Packings and Beds

Second of two articles on gas-liquid flow through random-packed towers. Here the author discusses empirical methods enabling you to determine pressure drop, flooding, liquid holdup and loading.

MAX LEVA, Consulting Chemical Engineer, Pittsburgh, Pa.*

In the first article (*Chemical Engineering*, Feb. 1957, p. 263) certain equipment features of gas-liquid flow through random-packed towers was presented. We will now discuss the more important and firmly established working correlations relating to flow through this system.

How The Series Is Organized

Random packed towers

- Gas-liquid system
- Liquid-liquid systems

Stacked towers

- Gas-liquid systems

Reactors

- Fixed bed
- Moving bed
- Fluidized bed

Pressure Drop

In non-irrigated towers carrying only a gas phase the pressure drop may be predicted by the following Kozeny-Carman type equation:

$$\Delta_P = \frac{2fG^2Z(1-\epsilon)^{3-n}}{D_p\phi_s^{3-n}g_c\rho_F\epsilon^3} \qquad (1)$$

For highly turbulent flow where n equals 2, the quantity $(1-\epsilon)/\epsilon^3D_p\phi_s$ is a function that depends wholly on the properties of the bed. Accordingly it has earlier been termed[3] bed characterization factor. It is useful for the purpose of making approximate packing comparisons.

Eq. (1) is not readily applicable to gas-liquid systems operating under elevated liquid rates. As already mentioned the irrigating phase will affect the effective voidage in the tower, the apparent and effective particle size and the shape of the particles will apparently be modified. All these factors as well as others influence the bed characterization factor in a complex way. For this reason development of a working correlation along these lines has not seemed practical thus far. Resort must then be taken to empirical approaches.

Irrigated pressure drop data in packed towers are of the type as shown in Fig. 1. Plotted on logarithmic coordinates the slope up to the loading point is essentially equal to 2.0 in accordance with the turbulent flow range in which most commercial packed towers operate. The parallel displacement of the several curves is due to varying liquid rates. Obviously the nature of this displacement is specific and precisely reflects the influence which liquid rate exerts on the bed characterization factor. For the branch up to the loading region an empirical correlation is readily apparent. Such a correlation will of course not hold for flow extending into the loading zone. There the slope increases beyond the value of 2.0 found valid for conditions below loading.

The question therefore arises how to correlate the data for this most important range where most towers operate. The clue to correlation is given by the relative constancy of the flooding point pressure drop and the proposed correlation of flooding data. If the standard flooding correlation describes a specific constant pressure condition through the tower then correlations for other constant pressure conditions in the tower (below flooding) should relate the data in a useful manner. At the same time the entire loading range is defined. This method of reasoning has been followed and applied to all available and to some new dumped-packing pressure drop data. The procedure has not only been applied to the loading range, but has also been extended below it. Thus an entirely generalized data presentation, showing packed tower operation and functioning in all its phases has been achieved.

Data correlation below the loading point has led to the following form of equation:

$$\Delta p = \alpha \times 10^{\beta L}(G^2/\rho) \qquad (2)$$

Constants α and β are characteristic of individual packings. The table lists α and β values for Raschig rings, Berl and Intalox saddles.

Voidage and Surface Area

These correlations apply up to the loading zone. As far as the lower irrigation limit is concerned

Nomenclature

D_p	Equivalent spherical particle diameter, ft.
D'_p	Nominal packing size, ft.
f	Modified friction factor, dimensionless
G	Gas flow rate, lb./sec., sq. ft.
g_c	Conversion factor, 32.2 (lb.mass/lb.force) (ft./sec.^{2}), or 4.17×10^8 (lb.mass/lb.force) (ft./hr.^{2})
H	Holdup, cu. ft. of liquid/cu. ft. of tower
L	Liquid flow rate, lb./sec., sq. ft.
n	State of flow factor, dimensionless
Z	Packed height, ft.
a	Specific packing surface area, sq. ft./cu. ft.
α, β	Constant (characteristic of packing see table)
Δ_P	Pressure drop, lb./sq. ft.
Δ_p	Pressure loss, in. water/ft.
ϵ	Bed voidage, dimensionless
μ	Absolute viscosity, lb./sec.-ft. or centipoises
ρ, ρ_F	Fluid density, lb./cu. ft.
ϕ_s	Sphericity factor of particles, dimensionless
ψ	Ratio, water density/liquid density, dimensionless

* For author biography see *Chem. Eng.* Jan. 1957, p. 294.

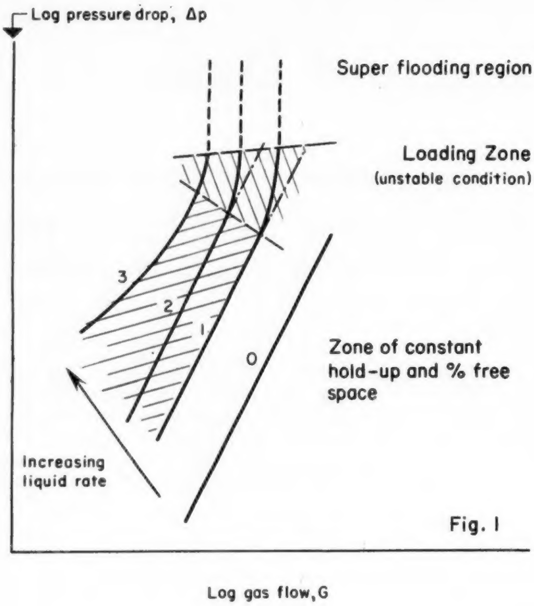


Fig. 1

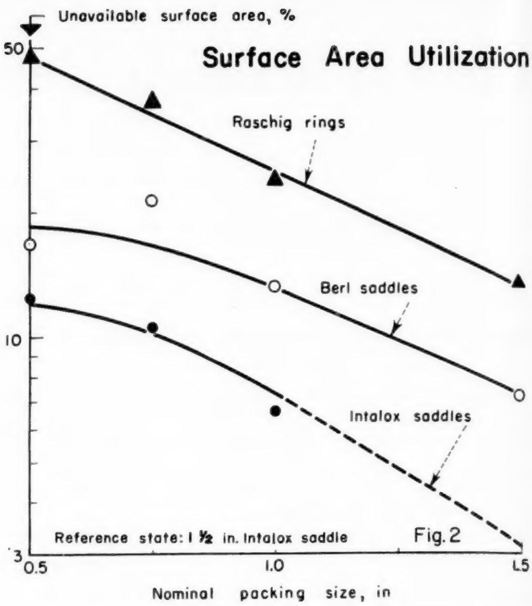


Fig. 2

they may be extrapolated to $L = 0$. For low irrigation rates, the predicted pressure drop for the voidage indicated in the table is in reasonably close agreement with values predicted by Eq. (1). Constant α may then be used like the bed characterization factor for packing comparisons, giving indications of the relative effectiveness of the free space in packings of various design.

Observations, in particular with mass transfer coefficients, have indicated that in the different kinds of packings, surface areas and void spaces are not equally effective. In other words certain void configurations (as determined by the parent packing elements and the mode of dumping) are preferred as fluid passages over others. In effect this is merely another way of defining channeling in a packed bed. The values in the table in combination with the bed characterization factor permit us to arrive at relative free space (and hence also surface area) utilization values for individual packings.

Free space utilization and general homogeneity of flow improve as packing size increases. Intalox saddles, owing to their special shape will form the most random bed. Consequently voidage utilization values are referred to the 1½-in. Intalox saddle because for this size α values are available for Raschig rings as well as Berl saddles. Letting α and $D_p\ \phi_s$ refer to any packing and using $D_p\phi_s = 0.230$ for 1½-in. Intalox saddles there is:

$$\frac{\alpha}{0.14} = \frac{(1-\epsilon)0.78^3 \times 0.230}{\epsilon^3 D_p\phi_s(1-0.78)}$$

Substitution of pertinent values of α and $D_p\phi_s$ in the above ratio permits evaluation of $(1\text{-}\epsilon)/\epsilon^3$ and hence the effective voidage ϵ_{eff}. The ratio ϵ_{eff}/ϵ where ϵ is the voidage shown in the table gives the utilization ratio. For the purpose of plotting it is more desirable to relate the quantity $(\epsilon\text{-}\epsilon_{eff})/\epsilon$ on semi-logarithmic coordinates to nominal packing size. This indicates then the fraction of the original gross voidage which is not effective. The graph will also permit extrapolation to 1½-in. Intalox saddles and thus let you ascertain an apprixi-mate value of $(\epsilon_{eff})/\epsilon$ for this packing. This value may then be used again to recalculate the values for the other packings. The correction thus applied would, however, be nominal.

The voidage and surface area utilization values derived by this method and shown in Fig. 2 will strictly apply to only non-irrigated packings. The complex effect of liquid rate decidedly influences the bed characterization factor. These values should nevertheless be satisfactory for indicating the relative order of magnitude of voidage and surface area utilization in packings in general. The method of analysis is outlined here because it will, afford a means of estimating effective packing areas if mass transfer coefficients become available for a system where the entire packing contributes to the surface area. Such systems would be similar to the wetted wall type equipment or the type of disk column which has been proposed by Stephens and Morris[9] for mass transfer research. In order for the method to be workable it appears that reliable pressure drop data must accompany the mass transfer measurements and that the systems must operate below the loading zone.

As far as application of the pressure drop correlations to practical design problems is concerned, it is well to recall that irrigation was accomplished by water. The effect of liquid density on the pressure drop has been discussed elsewhere[2]. The density effect is taken into consideration if the liquid rate is multiplied by the ratio $62.3/\rho_L$ where 62.3 lb./cu. ft. is the density of water and ρ_L that of the liquid in question.

Flooding

Pressure drop in dumped packings is in the neighborhood of three in. of water per foot when flooding takes place. From the relative constancy of the pressure drop in

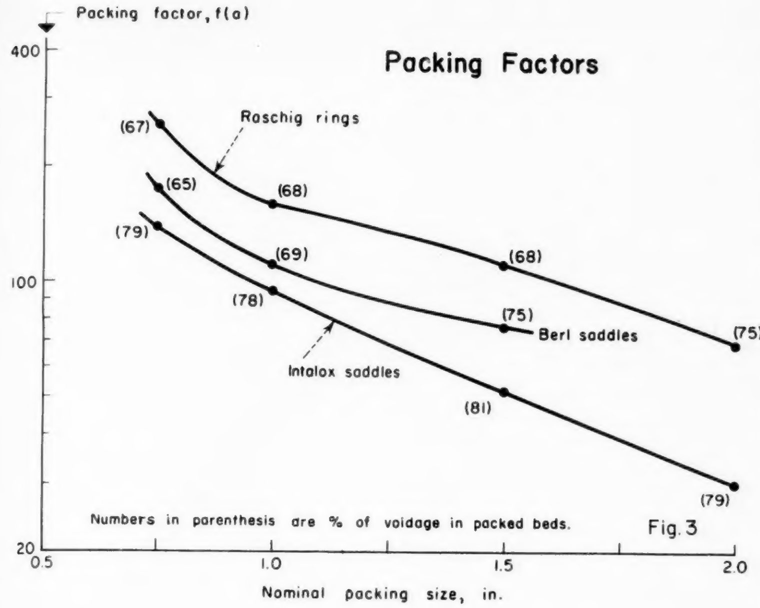


Fig. 3

relation to other variables (see Fig. 1) it is surmised that a substantial portion of this pressure drop is simply due to the presence of a hydrostatic head. Other components are fluid friction and expansion and contraction losses. These factors indicate how complex the analysis of flow can be at high liquid rates. Therefore, it is not surprising that the effect of liquid rate on the bed characterization factor can not be predicted. This will of course prevent absolute prediction of a packing factor and effectiveness of voids in high-rate irrigated towers. Accordingly flooding data have been largely correlated on an empirical basis.

The earliest far reaching correlation of Sherwood, Shipley and Holloway[7] has been improved by Lobo and coworkers[4] by suggesting improved packing factors. A further substantial improvement resulted by relating fluid velocities relative to each other rather than merely by referring them to the wall of the column. This correlation is given in Fig. 4. It applies to a wide range of sizes of dumped rings, Berl and Intalox saddles. Recommended packing factors are given in Fig. 3. They pertain to definite voidages as indicated. Estimates for slightly different voidages may readily be made. The use of the correlations will be discussed later in a typical problem.

The flooding line for dumped packings represents conditions in towers that are characterized by an almost constant pressure drop. Then the suggestion to present irrigated packed tower pressure drop data in a general way is quite obvious. Accordingly the other curves of Fig. 4 pertain to sub-flooding pressure drops. They cover virtually the entire packed tower operating range. The curves pertaining to the loading range are particularly helpful, since for this range there seem to be no coordinated formulae which permit pressure drop estimates. The sub-flooding curves will give quick estimates of pressure drop that are in good agreement with the data predicted by the earlier mentioned equations.

The data underlying the correlations of Fig. 4 extend over a liquid density range from about 50 to 76 lb./cu. ft. Indications obtained from applications are that Fig. 4 may be employed for predicting flooding in systems that carry liquids of even higher density. Regarding the other physical properties of the ordinate of Fig. 4 their effects on flooding have been ascertained in earlied studies. However, the ordinate does not contain a surface tension term. This is interesting since it has become apparent that liquid surface tension seems to be important.[5]

Liquid Holdup

Below the loading point liquid holdup in packed columns is almost unaffected by gas flow rates. As the loading point is approached a

Here You Get Values to Determine Pressure Drop . . .

$$\Delta p = \alpha \times 10^{\beta L} \times G^2/\rho$$

Packing	Nominal Size, In.	α Values	β Values	ϵ, Voidage in Packed Beds, %
Raschig rings	0.375	4.7	0.41	57
	0.50	3.1	0.41	59
	0.625	2.3	0.26	67
	0.75	1.4	0.26	72
	1.00	0.96	0.25	69
	1.25	0.57	0.23	76
	1.50	0.39	0.23	76
	2.00	0.24	0.17	82
Berl saddles	0.50	1.20	0.21	63
	0.75	0.62	0.17	71
	1.00	0.39	0.17	71
	1.50	0.21	0.13	70
Intalox saddles	0.50	0.82	0.20	77
	0.75	0.47	0.16	75
	1.00	0.31	0.14	74
	1.50	0.14	0.14	78
	2.00	0.08	0.14	80

Empirical Relationship

$$\frac{G^2 f(a) \psi^2 \mu^{0.2}}{\rho_G \rho_L g_c}$$

Helps to Find Irrigated - Tower Pressure Drop for Dumped Packings . . .

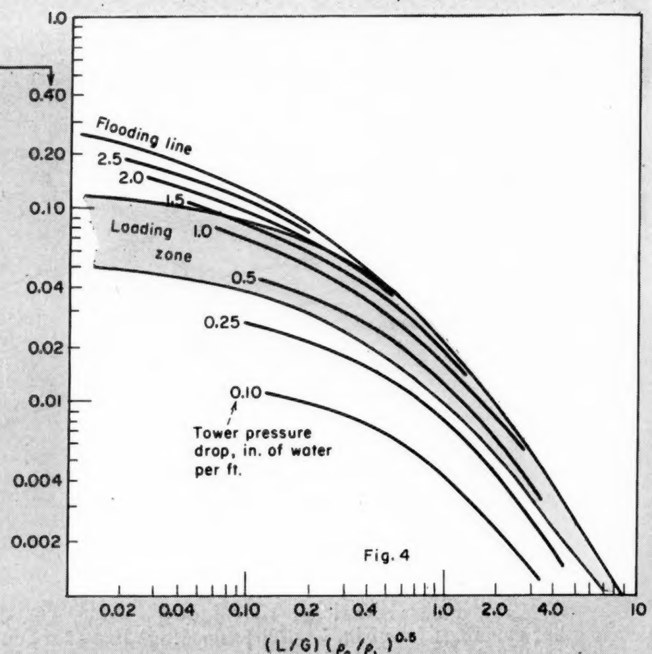


Fig. 4

mutual gas-liquid holdup effect manifests itself.

Estimates of liquid holdup are usually not required in packed tower design calculations where absorptions are involved. It may be an occasional requirement in batch fractionating columns where holdup in the column will then give an indication of how far a certain charge may be processed. Holdup data will also be required for estimating the response of a system to changes in operating conditions. Finally holdup studies seem to point the way toward an improved understanding of the mass transfer processes in packed towers.[8]

A recent comprehensive correlation of holdup data has been proposed by Otake and Okada[6]. It is proposed that

$$H = 1.295\left(\frac{D'_p L}{\mu}\right)^{0.676} \left[\frac{(D'_p)^3 g_c \rho^2}{\mu^2}\right]^{-0.44} (aD'_p) \quad (3)$$

The equation is applicable for the Reynolds number range 10-2,000. Of course gas flow is such that the column operates below loading.

It is claimed that the correlation covers virtually all literature data, which in addition to data pertaining to water would also include holdup values for non-aqueous liquids. This is somewhat surprising since the correlation does not contain a term for surface tension. Perhaps, however, the surface tension effect on hold-up is smaller than was originally proposed by Jesser and Elgin.[1] (Compare with the holdup equations of Shulman et al.[8]) As far as effect of liquid viscosity is concerned $H \propto \mu^{0.2}$. This is in fairly good agreement with the findings of Jesser and Elgin ($H \propto \mu^{0.1}$) and more recently Shulman et al ($H \propto \mu^{0.13}$ and $H \propto \mu^{0.31}$).

Loading

The loading zone for dumped packings is denoted in Fig. 4. It covers a fairly wide range of pressure drops and this is compatible with the qualitative data of Fig. 1. As the irrigation rates increase the loading zone narrows and loading and flooding points tend to coincide. Obviously the operation of columns at very high irrigation rates can therefore become critical if designed to operate in this range.

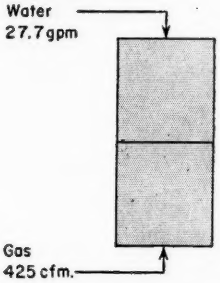
It is usually desired to operate a packed tower in the loading zone. The packing is then reasonably well wetted to give relatively favorable capacity data. At the same time holdups are low enough to cause only moderate gas pressure drops. With absorption columns considerable adjustments regarding operating range are possible. This is however not true with fractionation columns, where the liquid rate is dictated by the boil-up rate and the required reflux ratios. With distilling columns it is therefore not always feasible to design for the loading range and frequently columns must operate substantially below loading.

REFERENCES:

1. Jesser, B. W., J. C. Elgin, *Trans. A. I. Ch. E.* **39**, 277 (1943).
2. Leva, Max, Chem. Eng. Progress Symposium Series **50**, 10, 51-59 (1954).
3. Leva, Max, et al. U. S. Bureau of Mines, Bull. 504, 1951.
4. Lobo, W. E., et al, *Trans. A. I. Ch. E.* **41**, 693 (1945).
5. Newton, Mason, Metcalfe, *Petr. Ref.* **31**, 10, 141 (1952).
6. Otake, T., K. Okada, Soc. Chem. Engs. (Japan) **17**, 7, 261 (1953).
7. Sherwood, T. K., G. H. Shipley, F. A. L. Holloway, *Ind. Eng. Chem.* **30**, 765 (1938).
8. Shulman, H. L., et. al, *A. I. Ch. E. Journal*, **1**, 2, 247-64 (1955).
9. Stephens, E. J., G. A. Norris, *Chem. Eng. Progress* **47**, 232 (1951).

Problems Show How Empirical Relations Are Used . . .

Problem 1— Pressure Drop



A gas absorber of 2 ft. diameter is packed with 2 sections of 1-in. Raschig rings, each section being 10 ft. high and supported by a Weir-type support plate. The tower handles 27.7 gpm. of water and 425 cfm. of a gas of average density 0.66 lb./ft.^{3}.

For the conditions stated find the tower pressure drop and establish the state of loading of the system.

Solution—Fluid rates are as follows:

Gas:

$$\frac{425 \times 60 \times 0.066}{3.14} = 535 \text{ lb./ft.}^2\text{, hr.}$$

Liquid:

$$\frac{27.7 \times 8.33 \times 60}{3.14} = 4{,}400 \text{ lb./ft.}^2\text{, hr.}$$

From the above conditions it is anticipated that the tower may essentially operate in the loading zone and hence Fig. 4 is used.

Abscissa:

$$\frac{L}{G}\sqrt{\frac{\rho_G}{\rho_L}} = \frac{4{,}400}{535}\sqrt{\frac{0.066}{62.3}} = 0.268$$

Ordinate:

(Assuming $\mu = 1$ cp. and $\psi = 1.0$)

$$\frac{G^2 f(a)\psi^2\mu^{0.2}}{\rho_G\rho_L g_c} = \frac{(535)^2 \times 160 \times 1 \times 1}{0.066 \times 62.3 \times 4.17 \times 10^8} = 0.0267$$

From Fig. 4, $\Delta p = 0.4$ in. water/ft. and the tower operates in the lower loading zone.

The pressure drop across the entire packing is then 20 x 0.4 = 8 in. of water. This has to be augmented by the pressure drop through two support plates which per plate amounts to about 0.3 in. of water column. The entire pressure drop is therefore about 8.5 to 9 in. of water column.

Problem 2— Effect of Saddles

For the flow conditions given in Problem 1 and the tower dimensions as stated the 1-in. Raschig rings are replaced by 1-in. Intalox saddles. What will then be the new column pressure drop and also what will be the variation in column holdup when making the change.

Solution—Again resort is taken to Fig. 4. The value of the abscissa remains the same and the ordinate varies as the packing factors. The packing factor for 1-in. Intalox saddles, as evaluated from Fig. 3 is equal to 95 and the ordinate pertaining to Fig. 4 then becomes equal to

$$0.0267 \times \frac{95}{160} = 0.0159.$$

For the abscissa equal to 0.268, Fig. 4 reports a pressure drop of about 0.2 in. of water column per foot. Taking account of the total packing height and support plates the total pressure drop becomes then about 4.5 to 5 in. of water column.

The holdup may be estimated by Eq. (3), provided the liquid flows are in the proper range as characterized by the Reynolds number.

The liquid flow Reynolds number is found to be equal to

$$N_{Re} = \frac{1 \times 4{,}400}{12 \times 2.42} = 151,$$

which is in the proper range.

Hence applying Eq. (3) to 1-in. Raschig rings and to 1-in. Intalox saddles there results for

Raschig rings:

$$H = 1.295 \times (151)^{0.676} \times \left(\frac{4.18 \times 10^8 \times 62.3^2}{1{,}728 \times 2.42^2}\right)^{-0.44} \times \frac{58}{12} = 0.047 \text{ ft.}^3/\text{ft.}^3$$

Intalox saddles:

$$H = 1.295 \times (151)^{0.676} \times \left(\frac{4.18 \times 10^8 \times 62.3^2}{1{,}728 \times 2.42^2}\right)^{-0.44} \times \frac{78}{12} = 0.063 \text{ ft.}^3/\text{ft.}^3$$

With a packed volume of 3.14 × 20 = 62.8 cu. ft. the holdup then becomes 0.047 × 62.8 = 2.95 cu. ft. of water for the Raschig rings and 0.063 × 62.8 = 3.95 cu. ft. for the Intalox saddles.

By experiment in a pilot plant tower it has been found that for this liquid rate the Raschig ring holdup was 0.051 and the Intalox saddle hold-up 0.063 cu. ft. of liquid per cubic foot of packing.

Problem 3— Below the Loading Zone

A tower 20 ft. high scrubs a gas whose average density is 0.075 lb./cu. ft. The tower operates below the loading zone and handles 500 lb./hr., sq. ft. of the gas. The water rate is 3,000 lb./hr., sq. ft. Compare the gas pressure drop for each of the following packings: 1-in. Raschig rings, 1-in. berl saddles and 1-in. Intalox saddles.

Solution—Since the tower operates below the loading zone, Eq. (2) applies.

$$\Delta p = \alpha \times 10^{\beta L} G^2/\rho_G$$

From the table we obtain values of α and β which apply to 1-in. Raschig rings. Next we calculate the liquid and gas rates in lb./sec., sq. ft.

$$G = 500/3{,}600 = 0.139 \text{ lb./sec., sq. ft.}$$
$$L = 3{,}000/3{,}600 = 0.833 \text{ lb./sec., sq. ft.}$$

Substituting these values in the equation gives

$$\Delta p = 0.96 \times 10^{0.25 \times 0.833} \times (0.139)^2/0.075$$
$$\Delta p = 0.398 \text{ in. water column/ft. of tower}$$

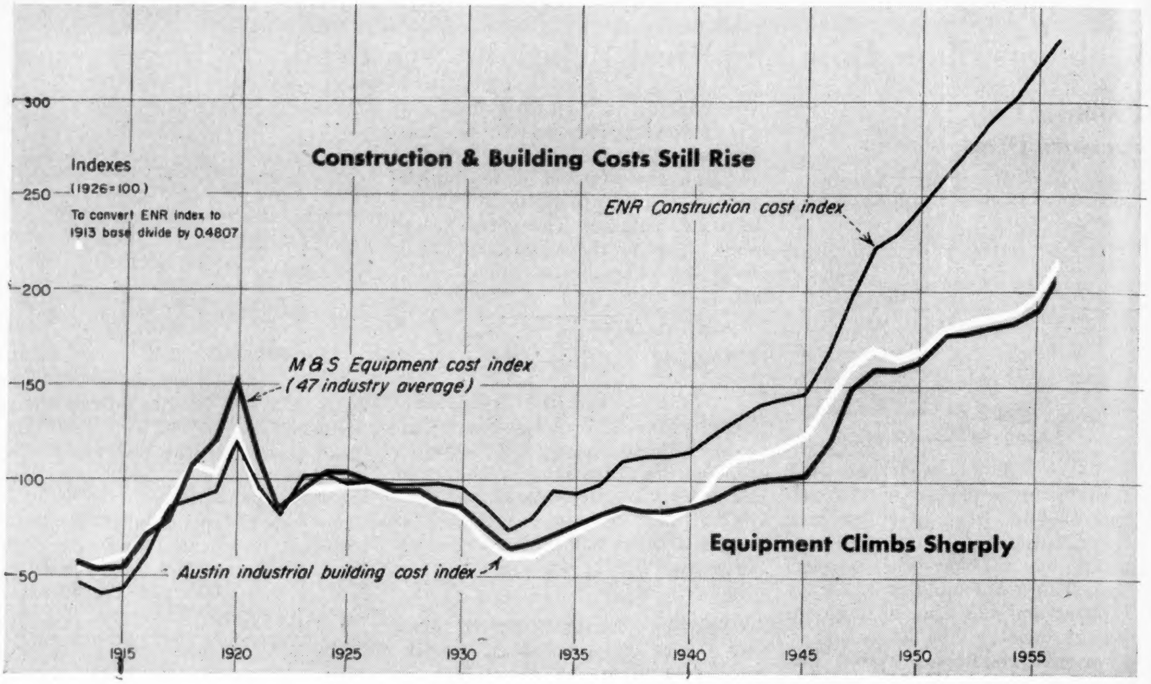
Hence the total pressure drop for the tower equals 0.398 × 20 = 7.96 in. of water column.

In a similar manner we calculate the pressure drop for 1-in. berl saddles and 1-in. Intalox saddles. The pressure drop is 0.140 and 0.105 in. of water column per foot of tower respectively.

Coming: Flow in stacked towers . . .

Next month's installment continues the series on gas-liquid contacting. Arrangement, installation and performance of rings and grids in stacked towers is presented.

Also discussed will be the relative performance of liquid distributors, and comparative capacity data for several types of stacked packings.



Equipment Cost Rise Accelerates

Tabulated below are the annual average indexes of comparative equipment cost for eight process industries and four related industries, prepared by the evaluation engineering firm of Marshall and Stevens, Incorporated of Illinois, Chicago 4. Extending from 1913 through 1956, the annual averages are supplemented by the quarterly figures on the individual charts at the right.

A tabulation each month, in the Process Equipment section, shows latest revisions for the quarters ending March, June, September and December.

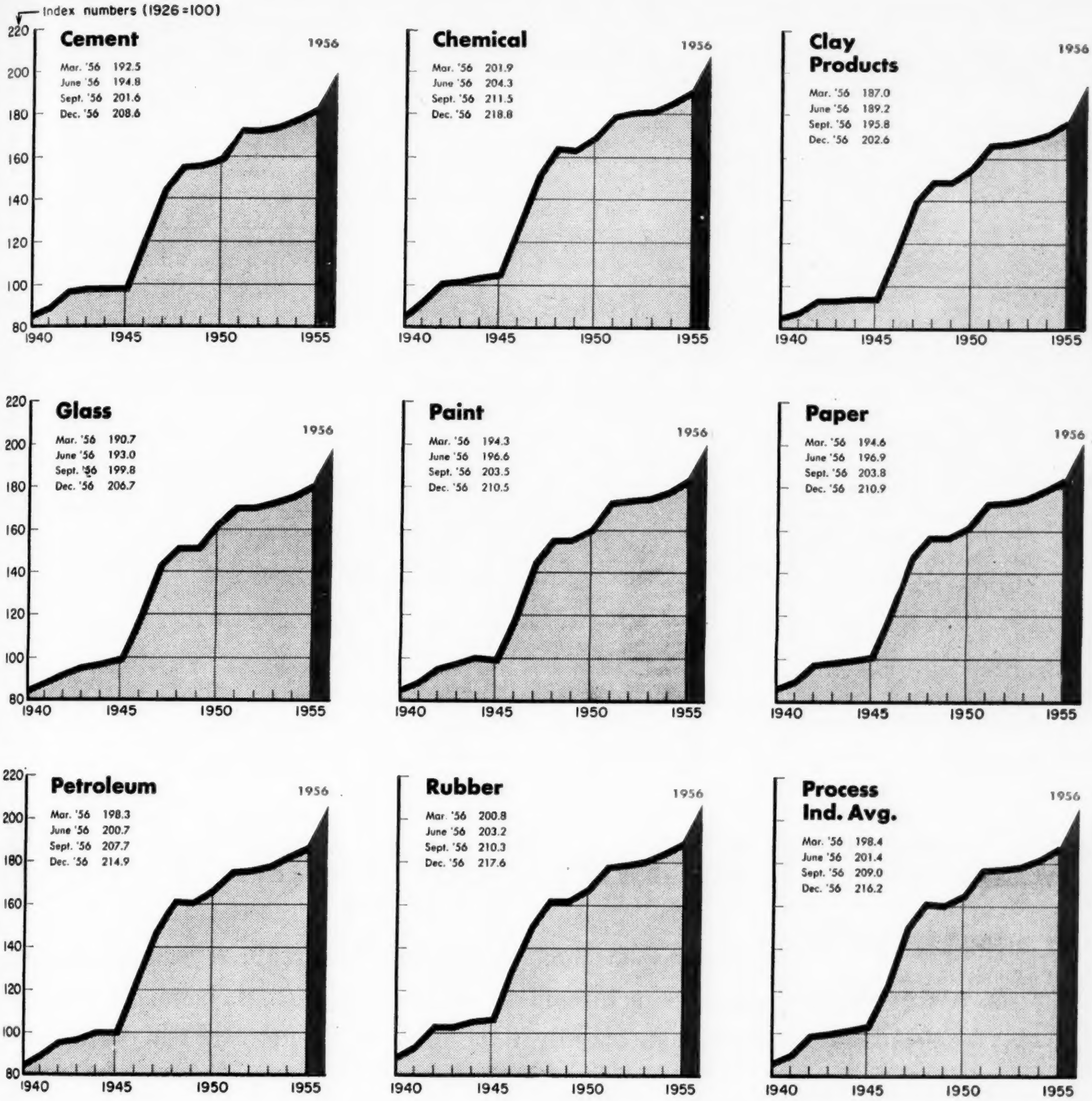
This feature was introduced initially on pages 124-6 of our November 1947 issue, in an article by the late R. W. Stevens, partner of the firm, which described the basis for the 47 industry indexes regularly issued by the firm, and the method of weighting the process industry average.

Charted above is the M & S 47-industry average plotted on the same grid with the Austin Co's index of industrial building costs, and the *Engineering News-Record* index of heavy construction costs.

All process industry components of the M & S index rose steadily during each quarter of 1956 forcing yearly averages to new highs.

Marshall and Stevens Annual Indexes of Comparative Equipment Costs, 1913 to 1956 (1926 = 100)

Industry	1913	1916	1918	1920	1922	1924	1926	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
Average of all	57.9	62.8	109.7	153.3	85.5	105.3	100.0	96.5	91.9	87.0	76.9	66.1	69.4	74.6	78.0	81.6	88.3	84.4
Process Industries																		
Cement mfg	58.0	62.5	109.1	149.2	83.7	104.6	100.0	97.2	92.5	87.0	76.8	68.9	70.7	75.7	78.1	82.2	88.8	85.2
Chemical	59.0	63.0	111.9	150.5	82.5	105.6	100.0	96.9	92.4	82.0	78.0	77.6	70.9	75.4	78.5	82.5	88.2	84.4
Clay Products	60.7	65.3	120.0	154.3	82.9	105.7	100.0	97.0	91.7	86.1	78.0	70.6	71.1	75.7	79.3	83.2	87.8	83.2
Glass mfg	58.7	63.5	112.1	151.1	83.7	101.9	100.0	95.9	92.1	86.6	77.9	69.4	71.2	75.4	78.5	82.6	88.0	83.4
Paint mfg	58.2	62.8	108.0	148.5	84.1	104.0	100.0	94.6	91.7	85.7	76.6	67.0	69.2	74.3	77.0	80.4	87.4	83.9
Paper mfg	60.4	63.4	111.8	152.6	83.1	105.6	100.0	96.8	90.9	86.5	77.1	67.2	69.9	75.4	78.5	82.7	88.1	84.8
Petroleum Ind	58.9	64.1	113.0	151.5	82.7	106.0	100.0	97.1	92.0	86.2	77.6	70.1	70.6	76.0	78.7	82.6	87.8	83.3
Rubber Ind	58.6	63.8	113.8	154.2	88.0	105.9	100.0	91.9	91.9	86.2	77.0	67.1	70.7	75.2	78.1	82.2	88.4	85.4
Related Industries																		
Elec. power equip	59.1	64.3	114.2	152.2	83.6	106.0	100.0	96.9	91.8	86.1	78.1	70.1	70.7	75.5	78.7	82.7	87.9	84.3
Mining, milling	56.8	62.9	111.9	149.9	82.8	105.6	100.0	97.2	92.9	86.7	76.8	67.6	80.0	85.6	88.5	92.4	97.1	92.6
Refrigerating	59.3	63.2	113.5	153.5	83.9	96.1	100.0	97.0	92.0	86.4	75.0	70.0	71.3	75.4	78.9	83.0	87.5	83.0
Steam power	59.1	64.3	114.2	152.2	82.7	106.1	100.0	96.9	91.8	86.2	88.1	70.1	70.7	75.5	78.7	82.7	87.0	82.2



1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	
84.3	86.1	92.6	99.6	100.5	102.4	103.4	123.2	150.6	162.8	161.2	167.9	180.3	180.5	182.5	184.6	190.6	208.8	..... Average of all
84.2	85.1	90.8	97.8	98.3	98.6	99.4	119.7	144.3	156.5	156.5	161.6	172.7	172.8	174.6	177.6	182.6	199.4	.... Cement mfg.
83.4	84.3	93.3	102.0	103.1	105.6	106.5	126.8	151.5	164.5	164.5	169.6	180.7	181.1	183.1	186.2	191.5	209.1	.... Chemical
82.3	83.4	87.6	93.1	93.6	93.9	94.8	115.0	139.8	151.5	151.5	156.6	167.7	167.8	169.5	172.4	177.3	193.8	...... Clay products
82.5	84.0	88.2	93.7	94.7	96.5	97.4	117.6	142.3	154.6	154.6	159.7	170.8	171.0	173.0	176.0	180.9	197.5	.... Glass mfg.
83.4	84.6	90.3	97.3	98.3	100.1	101.0	121.2	145.9	157.8	157.8	162.9	174.0	174.4	176.3	179.3	184.3	201.2	.... Paint mfg.
83.7	84.8	90.5	97.5	98.7	101.3	102.2	122.4	146.9	158.1	158.1	163.2	174.3	174.7	176.6	179.6	184.6	201.5	.... Paper mfg.
82.1	82.5	88.2	95.2	96.7	100.0	100.9	121.6	147.1	160.9	160.9	166.0	177.1	177.6	179.7	182.8	188.0	205.4	...... Petroleum Ind.
84.9	86.0	94.2	102.7	103.7	105.5	106.4	126.6	151.2	163.3	163.3	168.4	179.5	180.0	182.1	185.2	190.5	207.9	.... Rubber
83.7	85.3	90.5	96.5	97.5	99.3	100.2	122.9	150.0	166.1	166.1	171.2	182.3	182.8	185.0	188.0	193.3	211.0	.. Elec. power equip
91.7	92.8	98 5	105.5	106.2	107.3	108.2	128.4	152.9	165.2	165.2	170.7	181.4	181.9	184.1	187.1	192.6	210.4	..... Mining, milling
81.8	82.7	89.0	95.8	97.0	100.2	101.7	125.7	163.2	176.6	175.8	185.2	200.1	200.7	202.8	204.8	211.6	234.3	...... Refrigerating
81.3	82.4	86.6	92.1	92.8	93.9	94.8	116.0	141.7	153.2	153.2	158.4	169.9	170.5	172.6	175.5	180.4	197.0	...... Steam power

Recipients of Awards for Chemical Engineering Achievement, 1933-1955

1933	Carbide & Carbon Chemicals Co.	The original award was made for producing commercially a large number of synthetic organic chemicals from petroleum and natural gas.
1935	E. I. du Pont de Nemours & Co., Organic Chemicals Dept.	For the successful industrial development of neoprene, synthetic camphor and certain other important chemicals and dyestuffs.
1937	Monsanto Chemical Co.	For developing the large-scale production and utilization of elemental phosphorus.
1939	Standard Oil Development Co.	For new chemical engineering processes and equipment to make available superfuels for aviation, as well as other valuable products synthesized from the hydrocarbons of petroleum.
1941	The Dow Chemical Co.	For the recovery from seawater of magnesium metal then sorely needed for aircraft and munitions.
1943	American Synthetic Rubber Industry	67 companies were honored for crowding into 24 months a project that in normal times would have required many years—a miracle of chemical engineering planning and construction.
1946	The Atomic Bomb Project	Awarded to 122 companies, universities and research organizations for contributing as prime contractors so significantly to the research and engineering responsible for this war-ending achievement.
1947	Merck & Co.	For successful pioneering in the large-scale production of streptomycin and other vital medicinals and, in a broader sense, for service to humanity.
1948	Shell Development Co.	For the successful synthesis of glycerine from petroleum for the first time on a commercial scale.
1949	Celanese Corp. of America	For the chemical engineering integration of its textile, plastics and chemical operations.
1951	Phillips Petroleum Co.	For pioneering development of high-abrasion carbon blacks, and major contributions to the success of cold rubber.
1953	Carbide & Carbon Chemicals Co.	For the first commercial production of certain aromatic chemicals directly from coal by high-pressure catalytic hydrogenation.
1955	Dow Corning Corp.	For the participation of its chemical engineers in all phases of the successful commercial development of silicone products.

Who Will Win This Year's ChE Award?

What company has done the most in the last three years to advance chemical engineering in industry and to encourage its chemical engineers to participate broadly in the affairs of the industry and profession?

To answer these questions is the responsibility of a committee of 90 senior chemical engineering educators serving under the chairmanship of Dr. Walter G. Whitman of the Massachusetts Institute of Technology, immediate past-president of the American Institute of Chemical Engineers. The ultimate decision of this committee will name the company in the chemical process industries that will receive this magazine's Fourteenth Biennial Award for Chemical Engineering Achievement.

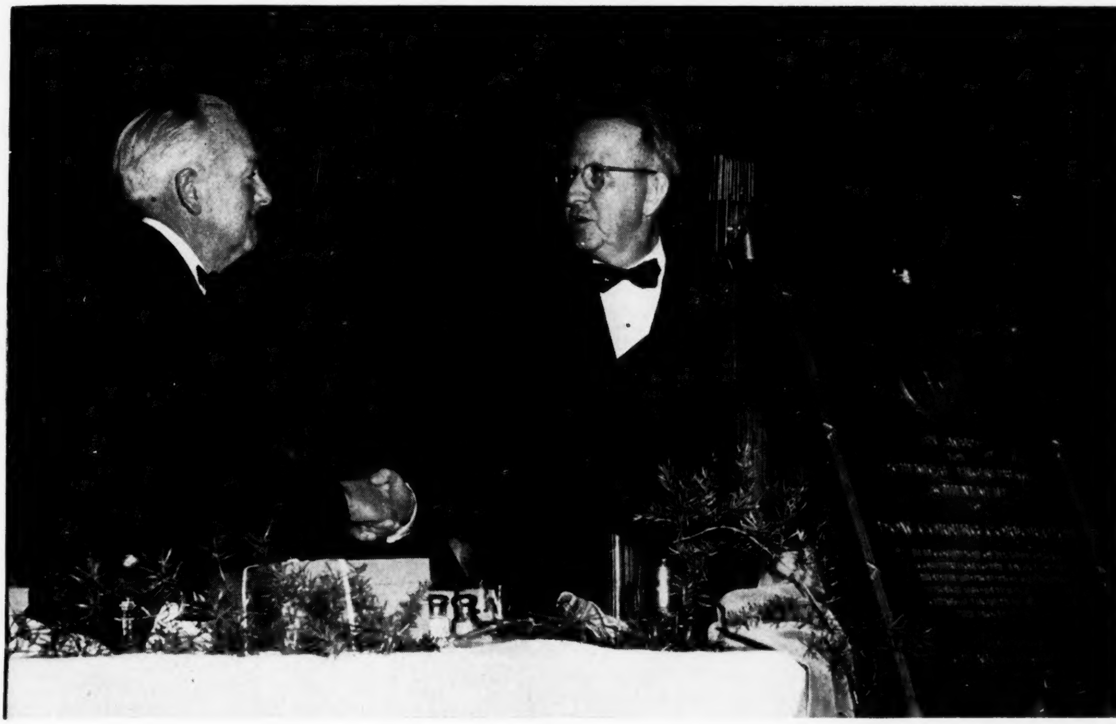
The distinguished role of the recipients of previous awards reflects the tremendous progress of the profession during the past quarter of a century. Beginning with the first large-scale commercial development of what we now call "petrochemicals," the list includes recognized pioneers in almost every field of chemical engineering enterprise — synthetic rubber, elemental phosphorus, sea-water magnesium, atomic energy, antibiotics and medicinals, textile fibers, plastics, silicones. But pioneering continues and by the same token there have been many more comparable developments during the past three record-breaking years.

You can greatly help the Award Committee by directing its attention to recent achievements of any company that would seem to qualify under the simple rules and regulations noted on these pages. A letter or postcard directed to the Secretary of the Award Committee or to its nearest member will be gratefully received. Here is your opportunity to cooperate in a project that has come to mean much for the chemical engineering profession. But remember that the deadline for all nominations is April 15, 1957.

Sidney D. Kirkpatrick

Secretary, Committee of Award

In 1955 . . . Dow Corning's W. R. Collings accepts award from Chairman Walter Whitman.



Rules and Regulations

Purpose—The Award for Chemical Engineering Achievement is to recognize the results of group effort—of teamwork among executives, engineering, research, production and sales divisions of a corporate organization. It is presented to a company, or to a department within a company, rather than to any individual. Thus it serves the dual purpose of (1) recognizing an outstanding group accomplishment and (2) at the same time calling attention to a company in the process industries that has encouraged its chemical engineers to participate in all of the affairs of the industry and profession.

Eligibility—The 1957 Award for Chemical Engineering Achievement will apply only to industrial developments that have come into commercial fruition or have become known publicly since January 1954. All nominations must be received by the Secretary of the Committee of Award not later than April 15, 1957. Subsequent presentations to the Award Committee should contain the following information:

(*a*) What is the nature of the company's achievement?

(*b*) During what period has it come into commercial fruition?

(*c*) To what extent have chemical engineers participated in its development?

(*d*) What are the supplementary records, data, articles, or references available to the Committee in order that it may give a fair consideration to this achievement and to the company personnel and employment policies?

Judges — The Committee of Award will consist of the heads of chemical engineering in all of the educational institutions of the United States whose courses are now accredited by the American Institute of Chemical Engineers and the Engineers' Council for Professional Development. Dr. Walter G. Whitman, chairman of the Department of Chemical Engineering at the Massachusetts Institute of Technology, who has been a member of the Award Committee since 1943, has again agreed to serve as our chairman. Sidney D. Kirkpatrick continues as secretary of the Award Committee but without vote.

The Award — The award shall consist of an appropriate bronze plaque suitably embossed to indicate the nature of the achievement and the name of the company to be honored. The award will be presented at a dinner of the chemical engineering profession to be held in New York City in connection with the 26th Exposition of the Chemical Industries during the week of December 2, 1957.

Your Participation — Nominations for this award are not restricted to those companies that file formal applications with the Committee. Suggestions are desired immediately from any and all sources that will help the Committee by directing its attention to companies and industrial groups that should have its careful consideration. Your communications may be addressed in confidence to Sidney D. Kirkpatrick, Secretary, Committee of Award, Room 2400, 330 West 42nd Street, New York 36, N. Y.

(See Award Committee next page.)

1957 Committee of Award

CHAIRMAN
Walter Gordon Whitman, Massachusetts Institute of Technology, Cambridge, Mass.

SECRETARY
Sidney D. Kirkpatrick, McGraw-Hill Publishing Co., Inc., New York 36, N. Y.

ALABAMA
C. A. Basore, Alabama Polytechnic Institute, Auburn.
K. W. Coons, U. of Alabama, University.

ARKANSAS
M. E. Barker, U. of Arkansas, Fayetteville.

CALIFORNIA
W. N. Lacey, California Institute of Technology, Pasadena.
C. R. Wilke, U. of California, Berkeley.

COLORADO
B. E. Lauer, U. of Colorado, Boulder.

CONNECTICUT
B. F. Dodge, Yale University, New Haven.

DELAWARE
R. L. Pigford, U. of Delaware, Newark.

FLORIDA
W. H. Beisler, U. of Florida, Gainesville.

GEORGIA
W. M. Newton, Georgia Institute of Technology, Atlanta.

IDAHO
M. L. Jackson, U. of Idaho, Moscow.

ILLINOIS
W. T. Brazelton, Northwestern University, Evanston.
H. G. Drickamer, U. of Illinois, Urbana.
R. E. Peck, Illinois Institute of Technology, Chicago.

INDIANA
S. G. Bankoff, Rose Polytechnic Institute, Terre Haute.
E. W. Comings, Purdue University, Lafayette.
R. E. Rich, U. of Notre Dame, Notre Dame.

IOWA
Karl Kammermeyer, State University of Iowa, Iowa City.
Morton Smutz, Iowa State College, Ames.

KANSAS
J. O. Maloney, U. of Kansas, Lawrence.
Henry T. Ward, Kansas State College, Manhattan.

KENTUCKY
G. C. Williams, U. of Louisville, Louisville.

LOUISIANA
R. V. Bailey, Tulane University, New Orleans.
W. W. Chew, Louisiana Polytechnic Institute, Ruston.
Jesse Coates, Louisiana State University, Baton Rouge.
R. G. Stevens, Southwestern Louisiana Institute, Lafayette.

MAINE
L. C. Jenness, U. of Maine, Orono.

MARYLAND
W. J. Huff, U. of Maryland, College Park.

MASSACHUSETTS
Chester P. Baker, Northeastern University, Boston.
L. B. Smith, Tufts College, Medford.
E. D. Wilson, Worcester Polytechnic Institute, Worcester.

MICHIGAN
H. G. Donnelly, Wayne University, Detroit.
C. G. Duncombe, U. of Detroit, Detroit.
C. F. Gurnham, Michigan State University, East Lansing.
Brymer Williams, U. of Michigan, Ann Arbor, Michigan.
R. F. Makens, Mich. Col. of Mining and Tech., Houghton.

MINNESOTA
N. R. Amundson, U. of Minnesota, Minneapolis.

MISSISSIPPI
F. A. Anderson, U. of Mississippi, University.

MISSOURI
G. H. Beyer, U. of Missouri, Columbia.
L. E. Stout, Washington University, St. Louis.
Dudley Thompson, School of Mines and Metallurgy, Rolla.

MONTANA
Lloyd Berg, Montana State College, Bozeman.

NEBRASKA
J. H. Weber, U. of Nebraska, Lincoln.

NEW JERSEY
C. L. Mantell, Newark College of Engineering, Newark.
R. H. Wilhelm, Princeton University, Princeton.

NEW YORK
L. S. Coonley, Rensselaer Polytechnic Institute, Troy.
A. H. Cooper, Pratt Institute, Brooklyn.
T. B. Drew, Columbia University, New York.
D. L. Green, Clarkson College of Technology, Potsdam.
John Happel, Jr., New York University, New York.
S. A. Miller, U. of Rochester, Rochester.
H. P. Munger, Syracuse University, Syracuse.
D. F. Othmer, Polytechnic Institute of Brooklyn, Brooklyn.
A. H. Radasch, The Cooper Union, New York.
A. X. Schmidt, The City College of New York, New York.
C. C. Winding, Cornell University, Ithaca.

NORTH CAROLINA
E. M. Schoenborn, North Carolina State College, Raleigh.

NORTH DAKOTA
A. M. Cooley, U. of North Dakota, Grand Forks.

OHIO
J. T. Cumming, Fenn College, Cleveland.
J. H. Koffolt, Ohio State University, Columbus.
William Licht, U. of Cincinnati, Cincinnati.
T. J. Walsh, Case Institute of Technology, Cleveland.

OKLAHOMA
R. H. Dodd, Oklahoma A and M College, Stillwater.
C. M. Sliepcevich, U. of Oklahoma, Norman.

OREGON
J. S. Walton, Oregon State College, Corvallis.

PENNSYLVANIA
James Coull, U. of Pittsburgh, Pittsburgh.
D. S. Cryder, Penn. State University, University Park.
F. A. Fletcher, Drexel Inst. of Tech., Philadelphia.
A. S. Foust, Lehigh University, Bethlehem.
E. L. McMillen, Lafayette College, Easton.
M. C. Molstad, U. of Pennsylvania, Philadelphia.
C. C. Monrad, Carnegie Inst. of Tech., Pittsburgh.
H. D. Sims, Bucknell University, Lewisburg.
R. E. White, Villanova University, Villanova.

RHODE ISLAND
A. R. Thompson, U. of Rhode Island, Kingston.

SOUTH CAROLINA
B. L. Baker, U. of South Carolina, Columbia.

TENNESSEE
R. M. Boarts, U. of Tennessee, Knoxville.
E. E. Litkenhous, Vanderbilt University, Nashville.

TEXAS
W. W. Akers, The Rice Institute, Houston.
J. D. Lindsay, The Agricultural and Mechanical College of Texas, College Station.
J. J. McKetta, U. of Texas, Austin.

UTAH
E. B. Christiansen, U. of Utah, Salt Lake City.

VIRGINIA
F. W. Bull, Virginia Polytechnic Institute, Blacksburg.
R. M. Hubbard, U. of Virginia, Charlottesville.

WASHINGTON
G. T. Austin, State College of Washington, Pullman.
R. W. Moulton, U. of Washington, Seattle.

WEST VIRGINIA
W. A. Koehler, West Virginia University, Morgantown.

WISCONSIN
R. A. Ragatz, U. of Wisconsin, Madison.

Predict Thermal Conductivity—II

Frequently required for design calculations, thermal conductivities are scattered through the literature. Now you can avoid the tiring search and calculate reliable values from basic fundamentals.

WALLACE R. GAMBILL, Carbide & Carbon Chemicals Co., Charleston, W. Va.*

Since it's difficult to select a single method of estimating engineering properties that is most suitable for all situations, the approach in this series of articles will be to at least allude to all pertinent correlations that we have found. In general, we'll present these in their order of accuracy or utility.

Some correlations with strictly limited applicability will be included, but in each instance the limitations are stated clearly.

Methods for Pure Liquids

We have already discussed (*Chem. Eng.*, Feb. 1957, p. 237) these five methods for estimating the thermal conductivity of pure liquids:

1. Sakiadis and Coates.
2. Palmer.
3. Smith's 1936 equation.
4. Weber.
5. Bridgman's equation.

This month we'll consider several other methods.

Method 6—Eyring and Coworkers

Eyring and coworkers[1,2] arrived at a semitheoretical equation for liquid thermal conductivity which, unfortunately, suffers from the same drawbacks as the Bridgman equation.

The Eyring equation contains not only a liquid acoustic velocity term, but also the ratio of specific heats, C_p/C_v, for the liquid:

$$k = \frac{2.793 k' V_a n^{0.667}}{\gamma^{0.5}} \qquad (a)$$

where k' is the Boltzmann constant (gas constant per molecule); V_a is the acoustic velocity in the liquid; n is the number density of the liquid, Ns/M, which is the same as the number of molecules per unit volume; γ is the ratio of specific heats of the liquid as found by velocity of sound measurements and has a value that is approximately equal to 1.0; N is Avogadro's number; s is the specific gravity of the liquid; and M is the molecular weight.

The constant in this equation was adjusted by semitheoretical means to bring the results more in line with experimental values. For 11 liquids, the maximum error was 26% and the mean error was about 10%. The numerical coefficient is about 12% less than that of Bridgman's equation when it is put in equivalent form, and the results are of slightly greater accuracy.

Eq. (*a*) contains the Eucken correction factor, $(9\gamma - 5)/4$, to take into account the internal degrees of freedom of polyatomic molecules. This equation gives approximately the correct temperature dependence of the thermal conductivity of liquids at 1 atm., but gives about twice the pressure dependence actually observed.

For monatomic liquids such as liquid metals or liquefied rare gases, we can use this corresponding equation:

$$k = \left(\frac{8}{\pi}\right)^{0.5} \frac{k' V_a n^{0.667}}{\gamma^{0.5}}$$

where the notation is the same as that in Eq. (a).

Method 7—Tsien

Tsien[3] gives an equation for liquid thermal conductivity that is derived by methods quite similar to those used by Bridgman, Eyring and others:

$$k = \frac{3RV^{0.333}}{V_l (s\beta)^{0.5}}$$

where R is the gas constant; V is liquid volume per molecule; V_l is molar liquid volume; s is liquid specific gravity; and β is the compressibility of the liquid in units of reciprocal pressure.

When put into conventional engineering units, Tsien's equation takes this form:

$$k = 0.01768 \frac{s^{0.167}}{M^{0.667}\beta^{0.5}}$$

where k is in Btu./hr.-ft.-° F.; s is specific gravity; M is molecular weight; and β is in atm. $^{-1}$.

When tested against data for 28 liquids, this relation gave a 13% mean deviation and a maximum error of 51%. We do not recommend the Tsien equation for general use. More accurate relations are available that don't contain the difficult-to-evaluate β term.

We might mention that Tsien correlates the β term by means of the following semitheoretical expression:

$$\beta = \frac{V_l}{RT_b[101.6 - 82.4(T/T_b)]}$$

where V_l is the liquid molar volume; R is the universal gas constant; and T_b is the normal boiling point on an absolute temperature scale.

An additional note of warning: This calculation is quite sensitive numerically if done by slide rule.

Method 8—Rao's Theory

Rao[4] proposed a theory for thermal conduction in liquids which is based on the hypothesis that the liquid state approaches the solid state more nearly than it does the gaseous state.

His equation for the thermal conductivity of a liquid—at its freezing point only—is:

$$k = 1.21 \frac{T_m^{0.5} s_m^{0.667}}{M^{1.167}}$$

where k is Btu./hr.-ft.-°F.; T_m is

* Mr. Gambill is now with the Union Carbide Nuclear Co., Oak Ridge, Tenn. To meet your author see *Chem. Eng.*, Feb. 1957, p. 324.

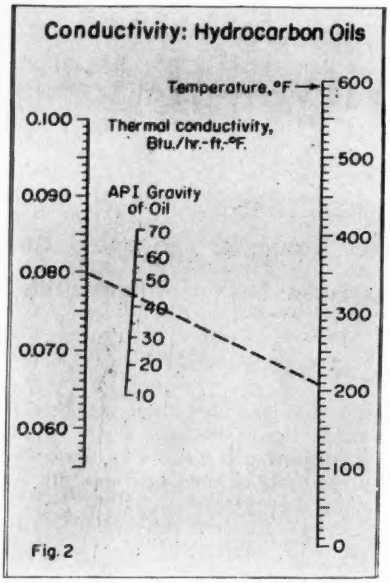


Fig. 2

the freezing point in °K.; s_m is the specific gravity of liquid at T_m; and M is the molecular weight.

For seven high-molecular-weight organics, Dick and McCready[5] found the calculated values to average about twice those observed. Since the equation applies only at the normal freezing point, it is somewhat restricted for ordinary usage because of the difficulty of evaluating the s_m term for low-melting-point substances.

Mohanty[6] proposed that for thermal conductivities of liquids at their melting points, the following equation be used:

$$k_m = 26.15\mu_m/M_v$$

where k_m is in Btu./hr.-ft.-°F.; μ_m is viscosity in centipoises; and M_v is the molecular weight of the vapor.

This rule gives a 13% variation for seven organic liquids and is recommended only for rough estimates.

Method 9—The Denbigh Relation

Denbigh[7] proposed a relation between the Prandtl number of a liquid and its entropy of vaporization. Thus, he indirectly relates thermal conductivity and latent heat of vaporization. In terms of k, the equation is:

$$k = 2.42C_p\mu/10^b$$

where the exponent b stands for:

$$(M\,\Delta H_v/17.87T) - 1.80$$

and where k is in Btu./hr.-ft.-°F.; C_p is in Btu./lb.-°F.; μ is in centipoises; M is the molecular weight; ΔH_v is the latent heat, in Btu./lb., at the normal boiling point; and T is temperature in °K. This relation gives an average error of about 30%, but high accuracy was not claimed for the work. Nor was it suggested that it be used for calculating thermal conductivity alone.

Method 10—Johnson and Others

Johnson, et. al.,[8] have presented an empirical plot of

$$k_T/k_{30C} \quad \text{vs.} \quad (T_c - T)/(T_c - T_b)$$

based on data for ten organic liquids.

This correlation is quite rough and gives wide variations; it is not recommended for general use in calculating temperature dependence of thermal conductivity.

Method 11—For Petroleum Fractions

For petroleum fractions, oils and hydrocarbon mixtures in general, there are four principle correlations available:

- Smith's recommendation.
- The Cragoe method, with nomograph.
- Via API gravity and the value of k^2C_ps.
- Smith's chart.

The simplest procedure is to use Smith's recommendation[9] that a constant value for k of 0.0791 Btu./hr.-ft.-°F. be assigned to all such substances for a temperature of 30 C. When comparing this with data for a series of oils at 30 C., Smith found an average and maximum errors of 6% and 13% respectively.

Cragoe[10, 11] recommended that for such liquids, the following relation be used:

$$k = \frac{0.0677}{s}\,[1 - 0.0003(t - 32)]$$

where k is in Btu./hr.-ft.-°F.; s is specific gravity 60/60 F.; and t is temperature in °F.

The accompanying nomograph (Fig. 2) presents the Cragoe relation. This equation and the nomograph may be expected to give, for oils, average and maximum errors of 12 and 39%, respectively. The range checked experimentally is 0.78 to 0.95 for specific gravity and 32 to 392 F. for temperature.

It has been noted[12, 13] that for an oil of a given API gravity at room temperature, the group (k^2C_ps) varies but little over wide temperature ranges; and that the thermal conductivity may be evaluated— if API gravity, C_p and s are known—from the following tabulation:

API Gravity (60/60 F.)	k^2C_ps
10	0.001859
20	0.002057
30	0.002340
40	0.002570

where k is in Btu./hr.-ft.-°F., at the temperature at which C_p and s are taken; C_p is in Btu./lb.-°F.; s is specific gravity; and the API gravity is equal to:

$$(141.5/s) - 131.5 \text{ at } 60 \text{ F.}$$

This correlation appears to have a variation of only 2-3%, and since the relation is very nearly linear, linear interpolation is permissible.

A graph based on Smith's 1936 work is also available. We have reproduced this as Fig. 3 on the next page.

Method 12—Prasad's Assumption

Prasad[14], on the assumption that the mechanism of thermal conductance in liquids is the same as that for viscosity (following Eyring's theories) derived the relation $k = C_p\mu$. This would indicate a Prandtl number, $C_p\mu/k$, equal to unity.

For a great majority of liquids this is obviously not true, and a conductivity calculated by means of this equation would usually be at least 2 to 6 times the experimental value.

Certain qualitative conclusions can be correctly drawn from this relation in the case of simple, non-associated liquids, but little quantitative significance can be given it. The approximate validity of this relation for gases will be treated in a later section.

Methods for Mixtures

In the preceding discussion we've listed 12 methods that you can use to help you predict the thermal conductivities of pure liquids.

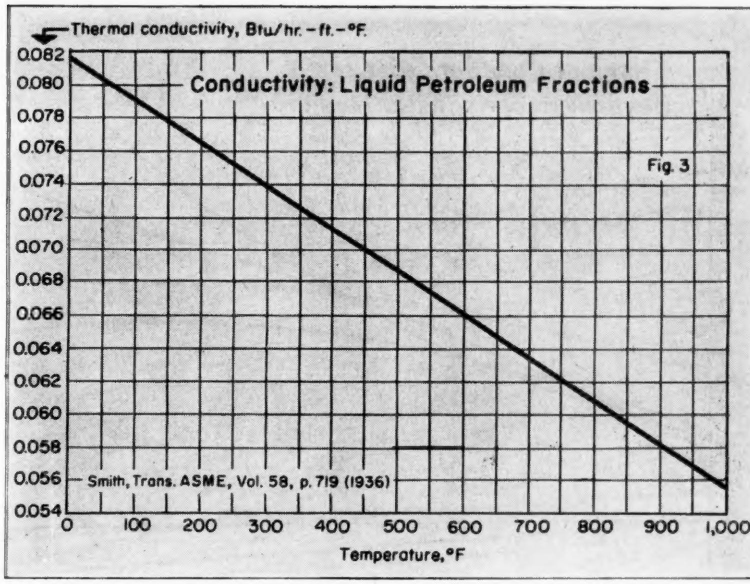
But what methods are available that will help you estimate this property for mixtures, either liquid-liquid mixtures or liquid-solid mixtures? We have found several that are of some value. They are:

- The Barratt and Nettleton proposal for binary mixtures of miscible liquids.
- The Grover and Knudsen expression for the effective thermal

conductivity of an immiscible binary liquid mixture.

- Tareef's electrical analogy for liquid-solid suspensions, with further confirmation by Orr and Dalla Valle.
- Kern's rules-of-thumb for liquid mixtures, solutions and liquid dispersions.

In addition, since many commercial heat transfer media are mixtures, we'd like to direct your attention once again to the plot that served as our frontispiece for this series. There are some additional notes of explanation that will make this chart more usable and more valuable to the reader.



Method 1—Barratt and Nettleton

For binary mixtures of miscible liquids, Barratt and Nettleton[15] proposed an equation that can be used to calculate the mixture conductivity. The equation relates, through hyperbolic sines, the thermal conductivities of the components in the mixture and of the mixture itself.

The Barratt and Nettleton equation is written in the following form:

$$k_m \sinh (100\, b) = k_1 \sinh (w_1 b) + k_2 \sinh (w_2 b)$$

where k_m is the thermal conductivity in Btu./hr.-ft-°F. for the mixture; k_1 is the thermal conductivity of component 1: k_2 is the thermal conductivity of component 2; w is the weight percentage equal to 100 times the weight fraction; and b is a constant specific to the constituents and independent of temperature in the ranges investigated.

To use this relationship, one value of mixture conductivity must, of course, be known in order to determine the constant b. Another drawback might be the uncomfortable feeling that comes over most chemical engineers when they have to deal with hyperbolic functions.

However, this equation is quite accurate, despite its simplicity. The accuracy was pointed out by Bates, Hazzard and Palmer in an article in the Analytical Edition of *Ind. & Eng. Chem.*[16]

Dale Davis presents a tabulation of percentage deviations of calculated from observed values for aqueous solutions of methanol, ethanol and glycerine.[17] He compares four compositions at each of three temperatures for each mixture. The average and maximum errors were 1.75 and −5.4%, respectively.

Method 2—Grover and Knudsen

Grover and Knudsen[18] have derived an expression for the effective thermal conductivity of an immiscible binary liquid mixture.

The equation was derived on the basis of a turbulently flowing mixture from concepts of forced convection heat transfer. It utilizes the Karman-Prandtl equation for thickness of laminar boundary layers at interfaces.

Conductivity values calculated in this manner should fit well into existent heat transfer film coefficient equations for turbulent flow, but might not represent the absolute value of conductivity, as for a motionless mixture.

The Grover and Knudsen correlation is given in this form:

$$k_m = k_1 k_2 \left(\frac{(\mu_1/s_1^{0.5})}{(\mu_2/s_2^{0.5})} + 1 \right) \Bigg/ \left[k_2 \left(\frac{(\mu_1/s_1^{0.5})}{(\mu_2/s_2^{0.5})} \right) + k_1 \right]$$

where μ is the viscosity; s is the specific gravity; and the subscripts m, 1 and 2 denote values for the mixture, component 1 and component 2, respectively.

Method 3—Tareef

For liquid-solid suspensions, Tareef[19], reasoning that the thermal field in a two-phase system is completely analogous to the electrical field in a similar system, used the results of Maxwell and other investigators for the electrical case.

Tareef wrote the following expression for the thermal conductivity of a liquid-solid suspension:

$$k_s = k_l\, a/b$$

where a represents:

$$2\, k_l + k_p - 2\, v\, (k_l - k_p)$$

and where b is:

$$2\, k_l + k_p + v\, (k_l - k_p)$$

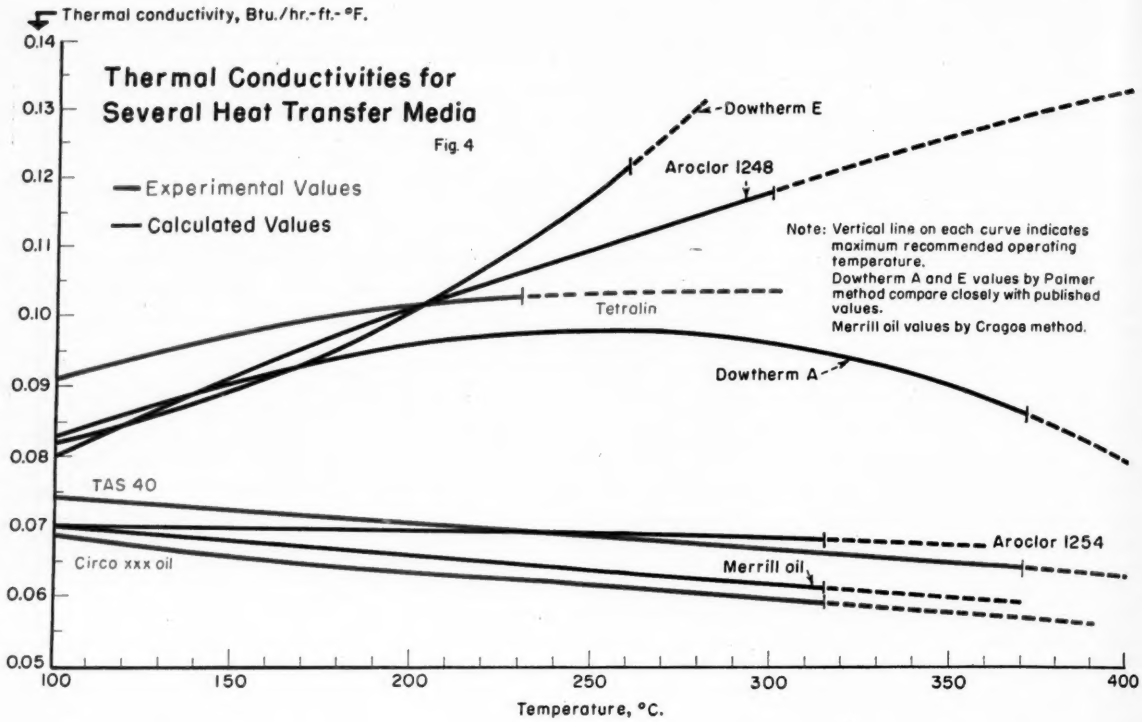
In the above equations, v is the volume fraction of solids in the suspension; and the subscripts s, l and p denote values for the suspension, the pure liquid and the suspended solid particles, respectively.

In a study of the heat transfer properties of suspensions, Orr and Dalla Valle[20] applied this expression to data of their own and of others and found excellent quantitative agreement.

Method 4—Kern's Rules

In his book "Process Heat Transfer" [McGraw-Hill Book Co., Inc., New York (1950)], D. Q. Kern suggests some rules-of-thumb that can be used to estimate thermal conductivities for liquid mixtures, solutions and dispersions.[21]

However, Kern admonishes the user of these rules that "Wherever laboratory tests are available or



data can be obtained, they will be preferable to any of the foregoing rules."

Kern's rules are as follows:

- For solutions of organic liquids, use an average conductivity, weighted by weight fractions. (This simple method was found to work well for three liquid organic mixtures by Cecil and Munch.[22])
- For solutions of organic liquids and water, use 0.9 times the weighted conductivity.
- For solutions of salts and water circulated through the shell of a heat exchanger, use 0.85 times the conductivity of water up to concentration of 30% by weight. (For a plot of the thermal conductivity of water, see *Chem. Eng.*, Feb. 1957, p. 238). Riedel[23] presents a considerable amount of data and a semitheoretical treatment for the thermal conductivity of aqueous solutions of strong electrolytes.
- For colloidal dispersions, use 0.9 times the conductivity of the dispersion liquid.
- For emulsions, use 0.9 times the conductivity of the continuous phase liquid surrounding the droplets.

With two or more known conductivity values, extrapolation to other temperatures may usually be made best by plotting thermal conductivity vs. temperature as a linear variation.

Notes on Gambill's Plot

As part of his work with the Carbide & Carbon Chemicals Co. at Charleston, W. Va., the writer prepared a report on the relative thermal effectiveness of some common high-temperature heat transfer media.

Fig. 4, above shows the variation with temperature of the thermal conductivities of several of these media. Experimental values were used for TAS 40, tetralin and Circo XXX heat transfer oil.

We used calculated values for Dowtherm A and E via the Palmer method. The resulting values compare quite closely with values published by the Dow Chemical Co.

The curve for Merrill oil was calculated by the Cragoe method. Curves for Aroclors 1,248 and 1,254 represent partial experimental data extrapolated by the author. As you will note from the footnote on the chart above, the vertical line on each curve indicates the maximum recommended operating temperature for that particular medium.

A similar curve can be plotted for HTS (heat transfer salt) with values calculated from heat transfer data in an article by Kirst, Nagel and Castner.[24] The method depends on the use of the Colburn film coefficient equation.

Methods for Solids

The large number of classes of solids and the variety of their behavior necessitates extensive subdivision when thermal conductivity is considered.

Jakob[25] presents a very comprehensive and concise review of present knowledge in this area. Types of solids considered include: porous or loose insulators; fine powders, amorphous and crystalline nonmetallic; building, refractory and electrical insulating materials; and metals and alloys.

Correlating variables include porosity or relative volumes of gas and solid phases, electrical conductivity and density.

We might mention a few generalities with respect to solids. For many types, the solid is actually a gas mass subdivided into small elements by a solid network of one form or another. The problem of

Thermal Conductivity of Common Woods

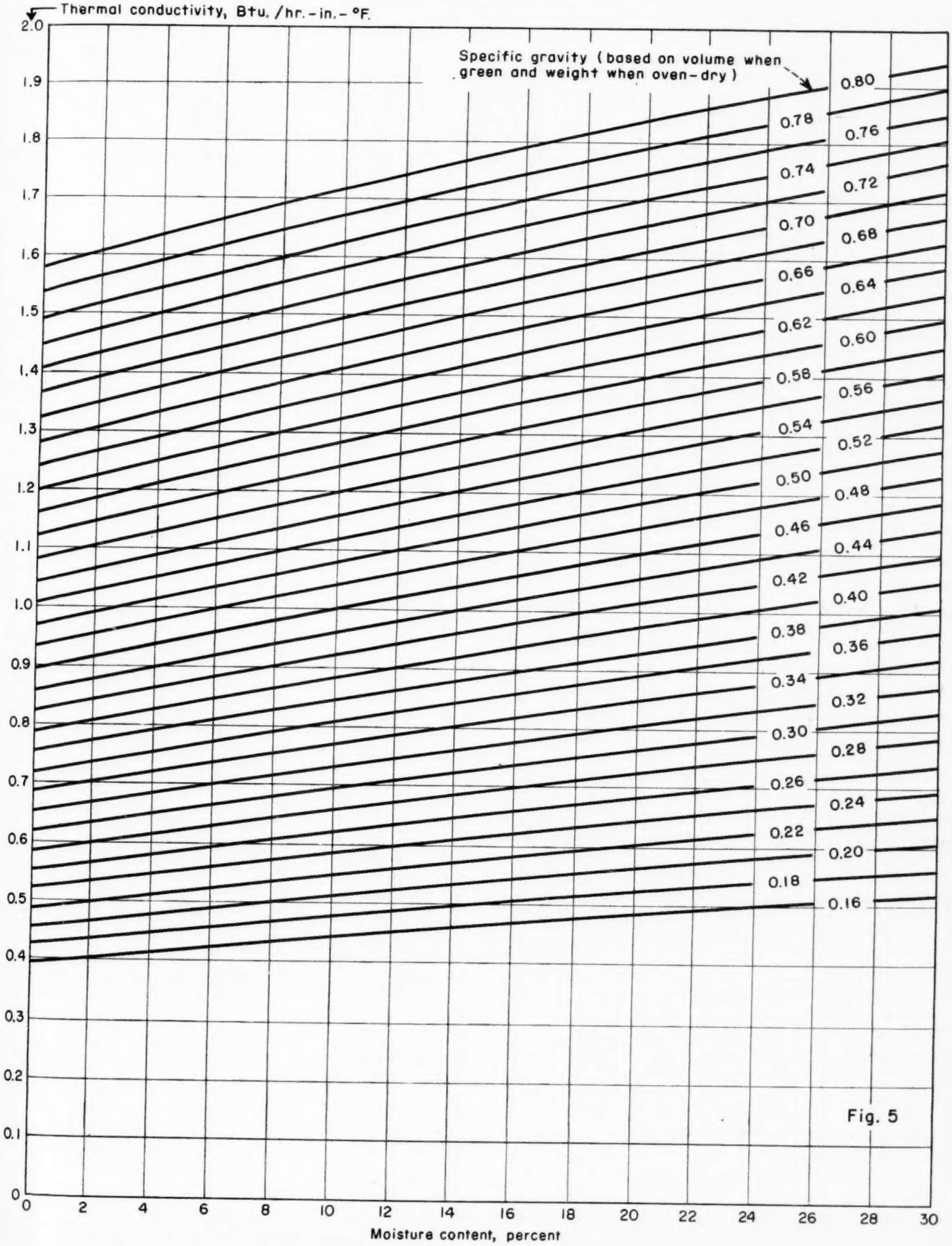


Fig. 5

determining the composite conductivity resolves itself into a relatively complex case of calculating radiation, convection, and conduction for the gas in the interstices of the solid.

Then this is combined—in a suitable manner—with the conduction effect of the solid.

In general, the greater the density of a particular type solid, the higher its conductivity. If homogeneous, conductivity varies nearly linearly with temperature over wide ranges for most solids.

And while it is difficult to predict in a particular case whether conductivity will vary directly or inversely with temperature, it appears that for most electrically insulating materials, k increases with temperature. On the other hand, for good conductors, k decreases with temperature.

For solids with a grain structure, such as wood or quartz, the conductivity parallel with the grain is apt to be two to four times that in a transverse direction.

Many experimental values for the conductivity of solids can be found in the literature.

Method 1—Metals

The well-known Wiedemann-Franz-Lorentz law relating the thermal and electrical conductivities of metals and their variation with temperature, may be stated as:

$$L_o = k\rho'/T$$

where L_o is the Lorentz constant and is approximately equal to 7 × 10^{-9}; k is in cal./cm.-sec.-°C.; ρ' is the electrical resistivity in ohm-cm.; and T is temperature in °K.

This relation applies only for crystalline, conductive solids at higher temperatures, and correlates only the electronic component of total conductivity of such materials. With this relation, k may be calculated for a given T if ρ' is known.

Method 2—Wood

For the particular and common case of woods, correlations have been proposed by Rowley[26], Maclean[27] and the Forest Products Laboratory of the U. S. Dept. of Agriculture.[28]

The Dept. of Agriculture method is the latest, the simplest and is given in the following form:

For moisture content less than 40%,

$$k = s\,(0.1159 + 0.00233\,M) + 0.01375$$

For moisture content of 40% or more,

$$k = s\,(0.1159 + 0.00316\,M) + 0.01375$$

where k is in Btu./hr.-ft.-°F.; s is the average specific gravity based on weight when oven-dry and volume when green, equal to density in gm./cc.; and M is the average moisture content in weight percent.

It is assumed that these conductivity values are for the case of heat flow normal to the grain direction. The accompanying chart (Fig. 5 on the previous page) is a graphical representation of the first equation above.

Note that the values of thermal conductivity given on the graph are in different units from those commonly used by chemical engineers. They should be divided by 12 to obtain Btu./hr.-ft.-°F.

Solid-Gas Mixtures

For the effective conductivity of a solid-gas mixture such as a fixed catalytic bed through which gas flows, several methods of estimation have been proposed.

Because of the comparatively recent activity in this field, we will not venture to rank these methods in order of importance, utility or accuracy. Instead we list them here for personal evaluation by the interested reader.

1. Bunnell, Irvin, Olson and Smith, "Effective Thermal Conductivities in Gas-Solid Systems," *Ind. & Eng. Chem.*, Sept. 1949, pp. 1,977-1,981.
2. Hougen, J. O. and E. L. Piret, "Effective Thermal Conductivity of Granular Solids Through Which Gases Are Flowing," *Chem. Eng. Progress*, June 1951, pp. 295-303.
3. Molino and Hougen, "Thermal Conductivity of Granular Solids Through Which Gases Are Flowing," *Chem. Eng. Progress*, March 1952, pp. 147-149.
4. Strickler, H. S., "Thermal Conductivity of Granulated Beds," *Ind. & Eng. Chem.*, 46, p. 828 (1954).
5. Argo, W. B. and J. M. Smith, "Heat Transfer in Packed Beds," *Chem. Eng. Progress*, 49, pp. 443-451 (1953).

Gases Next Month

We'll present the remainder of our discussion on predicting thermal conductivity in an early issue. At that time we'll consider methods that can be used for gases.

REFERENCES

1. Powell, R. E., Roseveare, W. E., and H. Eyring, "Diffusion, Thermal Conductivity and Viscous Flow of Liquids," *Ind. & Eng. Chem.*, **33**, pp. 430-435 (1941).
2. Glasstone, Laidler and Eyring, "The Theory of Rate Processes," McGraw-Hill Book Co., Inc., New York (1941).
3. Tsien, H. S., "The Properties of Pure Liquids," *J. Am. Rocket Soc.*, **23**, pp. 17-24, 35 (1953).
4. Rao, M., *Indian J. Physics*, **16**, pp. 161-167 (1942).
5. Dick, M. F., and D. W. McCready, preprint of paper entitled "The Thermal Conductivities of Some Organic Liquids," presented at annual meeting of ASME, Dec. 1953 (New York).
6. Mohanty, *Nature*, July 7, 1951, p. 42.
7. Denbigh, K. G., "Note on a Method of Estimating the Prandtl Number of Liquids," *J. Soc. Chem. Ind.*, **65**, pp. 61-63 (1946).
8. Johnson, Huang, Barry, Kemp and Lavergne, *Chem. in Canada*, Aug. 1954, p. 27.
9. Smith, J. F. D., *Trans. ASME*, **58**, pp. 719-725 (1936).
10. Cragoe, C. S., *Bur. of Standards Miscellaneous Publication No. 97* (1929).
11. Kirkbride, C. G., "Chemical Engineering Fundamentals," 1st. Ed., p. 373, McGraw-Hill Book Co., Inc., New York (1947).
12. Devore, A., and J. E. Heinz, "Viscous Oil Heat Exchangers," *Petroleum Refiner*, **32**, pp. 105-110 (1953).
13. Gambill, W. R. and C. H. Gilmour in course of heat transfer application work.
14. Prasad, B., "A Theory of Viscosity and Thermal Conductance of Liquids and Highly Compressed Gases," *Phil. Mag.*, **39**, pp. 884-889 (1948).
15. Barratt, T., and H. R. Nettleton, "International Critical Tables," Vol. V, p. 227, McGraw-Hill Book Co., Inc., New York (1929).
16. Bates, O. K., G. Hazzard and G. Palmer, *Ind. & Eng. Chem. (Anal. Ed.)*, **10**, p. 314 (1938).
17. Davis, D. S., "Chemical Engineering Nomographs," p. 30, McGraw-Hill Book Co., Inc., New York (1944).
18. Grover, S. S., and J. G. Knudsen, "Heat Transfer Between Immiscible Liquids," paper presented during Heat Transfer Symposium, Annual Meeting of AIChE, Dec. 1953 (St. Louis).
19. Tareef, B. M., "Thermal Conductivity of Colloidal Systems," *Colloid Journal of U. S. S. R.*, **6**, pp. 545-550 (1940).
20. Orr, C., Jr. and J. M. Dalla Valle, "Heat Transfer Properties of Liquid-Solid Suspensions," pp. 29-31 of "Heat Transfer Studies for 1954," *Chem. Eng. Progress Symposium Series No. 9*, Vol. 50, (1954).
21. Kern, D. Q., "Process Heat Transfer," p. 161, McGraw-Hill Book Co., Inc., New York (1950).
22. Cecil and Munch, *Ind. & Eng. Chem.*, **48**, pp. 437-440 (1956).
23. Riedel, L., *Chemie Ing. Technik*, **22**, (3), pp. 54-56 (1950); and **23** (3), pp. 59-64 (1951).
24. Kirst, Nagle and Castner, *Trans. AIChE*, **36**, pp. 371-390 (1940).
25. Jakob, M., "Heat Transfer," Vol. I, pp. 83-117, John Wiley & Sons, Inc., New York (1949).
26. Rowley, F. B., *Heating, Piping and Air Conditioning*, **5**, p. 313 (1933).
27. MacLean, J. D., *Heating Piping and Air Conditioning*, **13**, p. 380 (1941).
28. *Technical Note No. 248*, Dec. 1952, USDA, Madison 5, Wis.

REPRINTS

At convenient intervals, this series will be made up into reprint booklets. Please watch for the announcement of availability in an early issue. Use your Reader Service card for fastest service.

One man easily lifts two 20-foot lengths of Ryertex-Omicron PVC pipe 14" in diameter—proof of the amazing lightness that makes this corrosion resistant plastic easy to handle and install.

NEW FACTS ON PVC

(POLYVINYL CHLORIDE PLASTIC FOR PAPER MILL APPLICATIONS)

New booklet shows how this remarkable plastic solves tough corrosion problems

If your operation involves any corrosive element, it will pay you to get this new booklet on Ryertex-Omicron PVC . . . and investigate the 20-year record of the plastic that won't corrode, rot or "age." Here's what the booklet includes:

Data on properties—More than 280 commonly encountered corrosive solutions and gases to which Ryertex-Omicron PVC is resistant are listed in a table showing concentrations and temperatures. Advantages such as non-support of combustion, non-magnetic and non-sparking properties and low flow resistance are detailed. Maximum operating pressures of all sizes of Ryertex-Omicron PVC pipe are given and their weight per foot listed. (The plastic weighs only 1/6 as much as steel—½ as much as aluminum.) In short, the booklet answers hundreds of questions about how Ryertex-Omicron PVC may solve your toughest corrosion problems.

Injection molded globe valve of Ryertex-Omicron PVC. The same smooth finish on the inside assures maximum flow.

Typical applications—The ability of Ryertex-Omicron PVC to withstand temperatures of 165° F. in continuous service make it suitable for many applications previously barred to plastics. Moreover, it can be formed and welded as readily as metal. In

In chemical processing, Ryertex-Omicron PVC is recommended for: Tanks and tank linings, troughs, pipe lines for liquids or gases, fumes systems, blowers, roof ventilator housings, chutes, filter plates, splash covers, neutralizing acid equipment, cutter and drains, settling towers and scrubber towers—to name just a few of many applications.

Forms and sizes available—Rigid non-plasticized Ryertex-Omicron PVC.

SHEETS: Fully extruded sheets (not laminated) 1/32" through ⅜" thick, 40" wide x any length. Molded sheets ½" thick and heavier, 48" wide x 96" long.

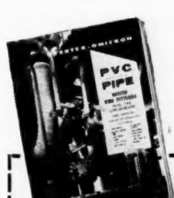
PIPE: Schedule 40 and schedule 80 pipe extruded in pipe sizes through 10". Larger sizes welded from pre-curved PVC sheets.

VALVES & FITTINGS: Injection molded and fabricated valves; socket type and threaded fittings; socket type, threaded and blind flanges for all pipe sizes. In addition we fabricate any type of special fittings to order.

RODS: Available in sizes up to 4" in standard 10' and 20' lengths.

RYERSON STEEL

INDUSTRIAL PLASTICS AND BEARINGS DIVISION



SEND FOR THIS BOOKLET

Our technical bulletin 80-3 will answer many of your questions about the properties, installation, etc. of Ryertex-Omicron PVC. Send for your copy today.

Joseph T. Ryerson & Son, Inc.
Box 8000-A
Chicago, Illinois

Please send me Bulletin 80-3

Name________________

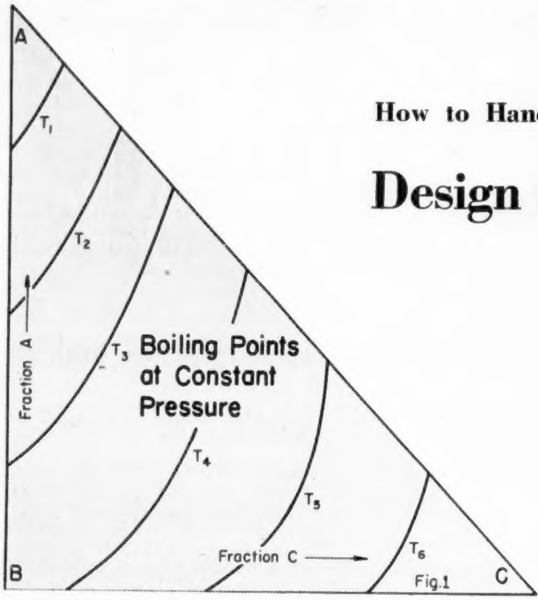
Company________________

City________________ Zone________ State________

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • WALLINGFORD, CONN. • PHILADELPHIA • CHARLOTTE, N. C. • CINCINNATI CLEVELAND • DETROIT • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

PRACTICE . . .

CE REFRESHER EDITED BY R. F. FREMED



How to Handle a Third Component When You . . .

Design for Physical Equilibrium

What happens to equilibrium when we have more than two components? Here's a guide to three-component vapor-liquid equilibrium relationships. (Part I)

JAMES O. OSBURN
State University of Iowa, Iowa City, Ia.*

PREVIOUS installments in this series on physical equilibrium (*Chem. Eng.*, Nov. 1956, p. 223; Dec. 1956, p. 211; Jan. 1957, p. 242; and Feb. 1957, p. 270) have stuck pretty much to two-component equilibrium. These subjects have been covered: representing phase behavior; extending available data; obtaining x-y data from boiling-point measurements.

We used two components as a starting point and remarked that these separations are the simplest. Often we can design process equipment by considering only the two major components that are being separated.

However, the mixtures we process generally contain several components, and the effect of these components isn't always negligible. In fact, for azeotropic and extractive distillation, we deliberately add a third component to effect a change in equilibrium.

* To meet your author, see *Chem. Eng.*, Nov. 1956, p. 415.

In this series, therefore, we plan to discuss what happens to equilibrium relationships when we have more than two components. This first installment—and a second to follow next month—will be limited to three-component vapor-liquid equilibrium. We'll try to answer these questions:

- How do we represent three-component equilibrium relationships?
- How is three-component equilibrium related to binary equilibrium of the components?
- How can we get equilibrium data from boiling points?

Phase Rule Governs Plotting

If we go back to the Gibbs phase rule for a moment, you'll recall that

$$P + F = C + 2$$

Then, with three components, we have $5 - P$ degrees of freedom; with one phase, four degrees; with two phases, three degrees; etc. But if we want to get our data onto a flat piece of paper, we have to hold two things constant.

When we design for three-component equilibrium, there are three composition variables; but these are related. If we know two of them, we can calculate the third by using this equation:

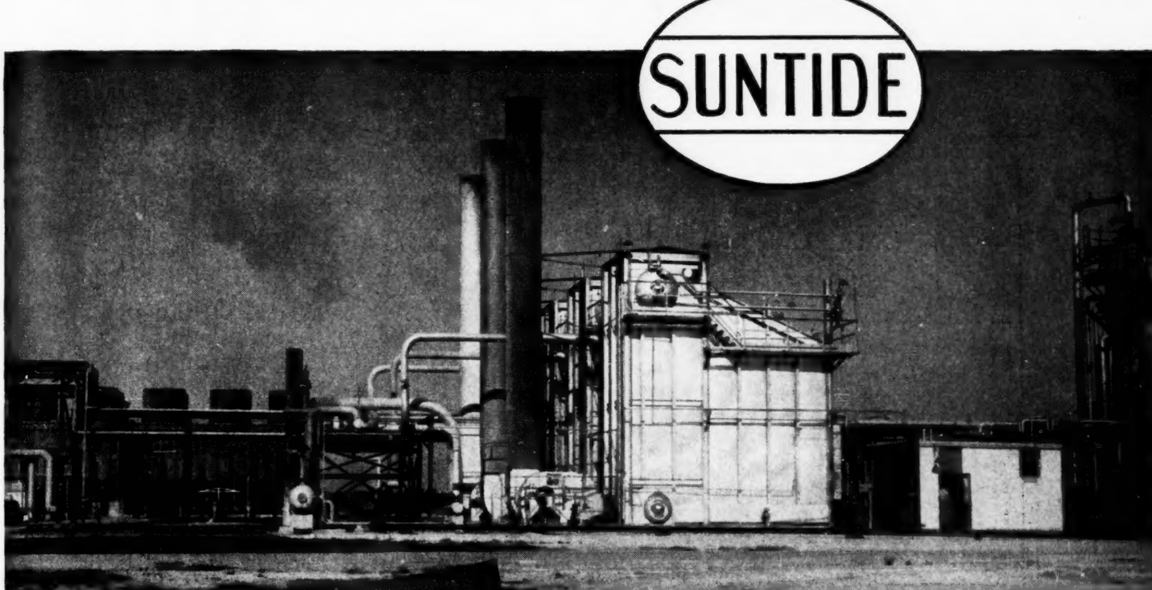
$$x_A + x_B + x_C = 1$$

Nomenclature (Consistent Units)

A, B, C	Pure substances in equilibrium
C	Number of components
F	Degrees of freedom
K	Equilibrium ratio
p	Partial pressure of
P	Number of phases
P	Vapor pressure of the pure substance indicated by the subscript
T	Absolute temperature
x	Mole fraction in the liquid phase
x'	Mole fraction in the liquid phase on a solvent-free basis
y	Mole fraction in the vapor phase
y'	Mole fraction in the vapor phase on a solvent-free basis
α	Relative volatility
π	Total pressure

Vogt STEAM GENERATORS

at SUNTIDE REFINING COMPANY
Viola, Texas



Above: *Cross Section showing arrangement of steam and water drums, tubes, baffles, and furnace.*

3 Units Installed
2 Units on Order

Principle Data Each Unit

- 85,000 pounds steam per hour capacity, designed for 500 lbs. S.W.P. and 625° F. total temperature.
- Water cooled furnace.
- Burners for Gas and Oil fuel.

Vogt offers a complete line of custom built and package type steam generators. Available in bent tube and straight tube designs for solid, liquid, or gaseous fuels burned singly or in combination.

Write for bulletins. Dept. 24A-BC

OTHER VOGT PRODUCTS

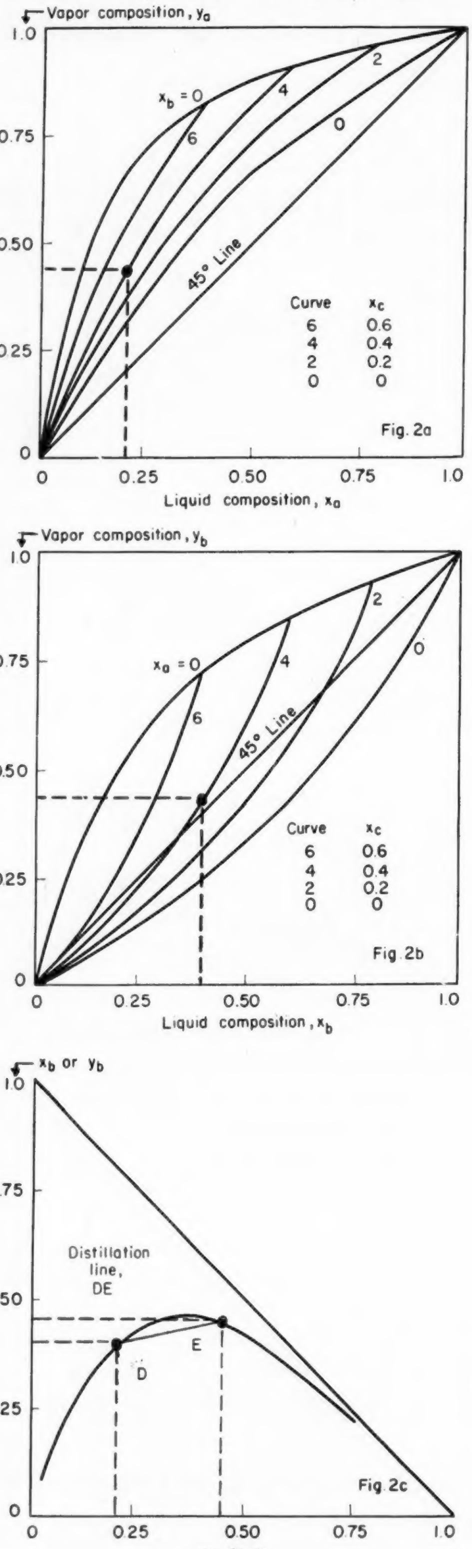
Drop Forged Steel Valves, Fittings and Flanges—
Petroleum Refinery and Chemical Plant Equipment
Heat Exchangers
Ice Making and Refrigerating Equipment

HENRY VOGT MACHINE CO.

Box 1918, Louisville 1, Kentucky

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati

Three Component x-y Diagrams



However, the temperature and the pressure may also vary independently. So, to represent the equilibrium we may choose various combinations of two variables, provided that we hold the other two constant. By holding pressure and temperature constant, we can reduce the number of variables to two composition terms.

For example, we can represent these as curves showing the boiling points of three-component liquid mixtures at constant pressure. We have shown such a plot on the previous page. It appears as a right-angle composition triangle. We can also use an equilateral triangle to represent three-component mixtures. The equilateral triangle allows us to read percentage composition of each component directly from the graph.

It's also correct to use ordinary rectangular coordinates to represent the equilibrium. Actually, this would be no different from the right-angle triangle. With such a plot we read two compositions from the graph and calculate the third.

Another Way to Plot Data

Again at constant pressure, we can hold constant the composition of one of the components in one phase (usually the liquid). For distillation we want to know the vapor composition for a given liquid composition. Therefore, the most-used diagram is the familiar *x-y* diagram.

In the panel at the left we have shown an *x-y* diagram for three components at constant pressure (Fig. 2a). Here y_A is plotted against x_A. When x_C is zero, we have the binary diagram for *A* and *B*. Other lines are obtained for various compositions of *C* in the liquid.

This diagram cannot tell the whole story, however. We can calculate x_B because x_A and x_C are known; but only one vapor composition is known.

We need a similar diagram to show another vapor composition (Fig. 2b). Here we show y_B for lines of constant x_C. To give the complete vapor composition, we need both Figs. 2a and 2b.

If we want to show the temperature, we must make a separate diagram.

Distillation Lines Aid Understanding

A way of plotting data to make them easier to visualize was introduced by Hodgson in *Research (London)*, Vol. 1, p. 568 (1948). He called the resulting curves "distillation lines."

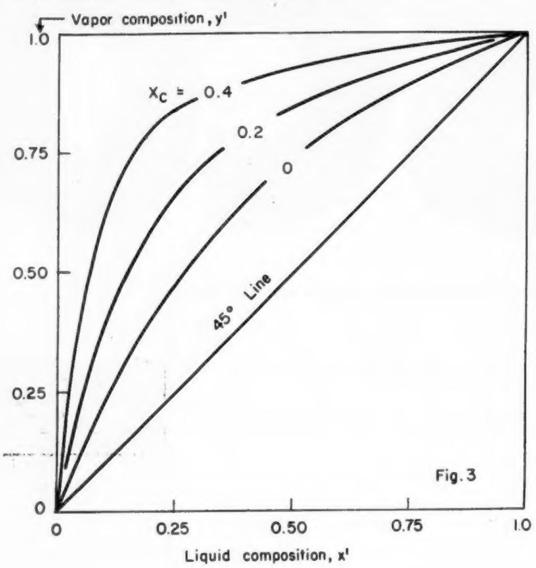
Distillation lines are drawn in such a way that liquid compositions and the equilibrium compositions are on the same line. We can understand this somewhat better if we try our hand at drawing an equilibrium line for the components used for Fig. 2.

In Fig. 2c let's choose a liquid composition at point *D*, which is at $x_A = 0.20$, $x_B = 0.40$, $x_C = 0.40$. Read y_A from Fig. 2a, and y_B from Fig. 2b. We get $y_A = 0.45$ and $y_B = 0.45$.

This is a point on the distillation line. By choosing several other points, the line containing *D* and *E* can be sketched in on Fig. 2c.

The distillation line represents the compositions of liquid and vapor in a packed column operating

Equilibrium: Solvent-Free Basis



at total reflux. But distillation lines don't show the temperature, and you can't find a vapor composition corresponding to a liquid composition.

Usefulness of distillation lines is in showing composition changes as they occur up through a distillation column.

Try the Solvent-Free Basis

Sometimes we are interested in separating two components, and the concentrations of the third component are of less importance. This is the case in extractive distillation, where we add a material, *C*, to help us separate the two main components, *A* and *B*, of a mixture.

Our first concern is with the degree of separation of *A* from *B*. So we construct a diagram on a solvent-free basis.

To do this we would allow phases to come to equilibrium, take samples, and remove all of the solvent, *C*, before analyzing them. The resulting compositions would be:

$$y_A' = y_A/(y_A + y_B)$$

and

$$x_A' = x_A/(x_A + x_B) \tag{1}$$

where the prime indicates compositions on a solvent-free basis.

To be useful as a separating agent, the solvent should change the equilibrium. Therefore, different lines are obtained for different solvent concentrations, as shown in Fig. 3 above. Fig. 3 shows the separating power of *C*, but we need another diagram to show equilibrium.

We Can Use Raoult's Law

We can use Raoult's law for many ternary mixtures of similar substances, or when we don't have any equilibrium data.

The treatment is very similar to that used for two-component systems (*Chem. Eng.*, Dec. 1956, p. 213). We use Raoult's law the same way for three or more components as we would for only two. The equations are as follows:

$$p_A = P_A x_A \tag{2}$$
$$p_B = P_B x_B \tag{3}$$
$$p_C = P_C x_C \tag{4}$$
$$\pi = p_A + p_B + p_C \tag{5}$$

When we know the total pressure and the liquid composition, we assume a temperature and calculate the partial pressures p_A, p_B and p_C. We adjust the temperature until the sum of the partial pressure equals the total pressure. Then we calculate the vapor composition of each component.

$$y = p/\pi \tag{6}$$

Relative volatility is defined in the same way that we defined it for a two-component system:

$$\alpha_{AB} = (y_A/x_A)/(y_B/x_B) \tag{7}$$

where the subscript indicates that we are considering the relative volatility of *A* compared to that of *B*.

We can also calculate relative volatilities for *A* compared to *C*; and for *B* compared to *C*. When Raoult's law applies,

$$\alpha_{AB} = P_A/P_B \tag{8}$$
$$\alpha_{AC} = P_A/P_C \tag{9}$$
$$\alpha_{BC} = P_B/P_C \tag{10}$$

On a *C*-free basis, the equation relating y' to x' can be written as:

$$y' = \frac{\alpha x'}{1 + (\alpha - 1)\,x'} \tag{11}$$

Equilibrium *K's* for Three Components

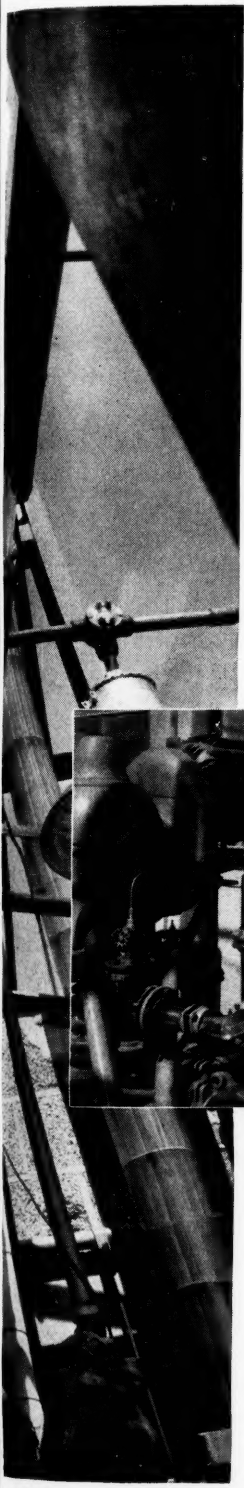
Equilibrium *K* values are more used for three or more components than for two. This method is a very convenient one for the cases where it applies.

Its greatest use is for mixtures of hydrocarbons. Although the solutions do not follow Raoult's law, the equilibrium vaporization ratios of a compound are not affected by the presence of other substances. We can plot *K* vs. temperature and pressure, and use it for any composition.

In a previous CE Refresher (*Chem. Eng.*, Dec. 1956, p. 214) we have already illustrated the use of the equilibrium vaporization ratios for predicting design requirements.

Next month we'll consider how to extend binary data to yield three-component equilibrium relationships; and how we can get three-component equilibrium data from individual boiling points.

chose PYREX brand shell and tube heat exchangers



The Carwin Company wanted heat exchangers in their isocyanate plant, that could live long and happily with an acidic solvent.

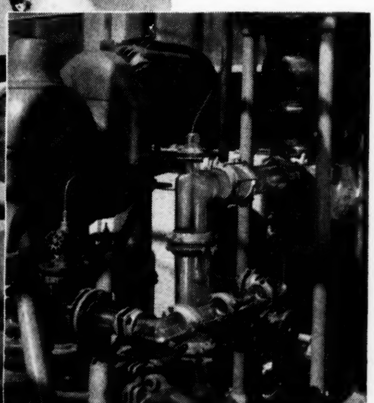
Comparing all available types, Carwin found 5 reasons in favor of PYREX brand glass shell and tube units. *First* was resistance to corrosion, indifference to chemical attack by all but HF and hot concentrated alkalies. *Second* was elimination of foreign material, which comes about because fluids contact only PYREX brand glass No. 7740, chemically resistant ceramic and Teflon.

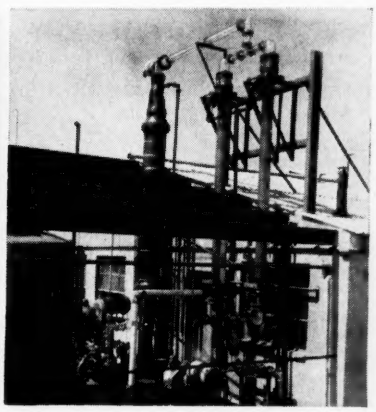
Third on Carwin's list came simplicity of design and easy maintenance. PYREX shell and tube units have no floating head or stuffing box to repair or repack. Dilute HCl removes scale, dirt and algae quickly. *Fourth* advantage was compactness. *Fifth* advantage—light weight. You need no special framework or supporting structure. Two men can easily handle the 50 sq. ft. size without cranes or hoists.

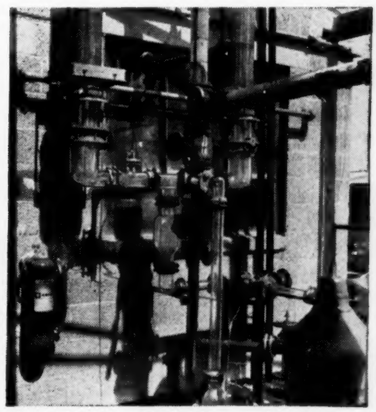
Add to features as important as these, such others as optional regenerative design, complete flexibility of installation, flow variation with external manifolding and exceptionally high, long-lasting heat transfer efficiency. (Tube wall conductivity coefficient [hw] = 260 b.t.u./hr. x ft.^{2} x °F.)

Many firms who have critical heat transfer problems now use PYREX brand shell and tube heat exchangers with excellent results. Wouldn't these units give you the most economical answers to your heat transfer problems, too?

May we give you more information so that you can weigh their merits in your processes? Send for Bulletin PE-33, "Design Manual for PYREX brand Modular Shell and Tube Heat Exchanger Units."







Details showing various heat exchanger hookups with PYREX brand glass pipe. Corning manufactures a complete line of PYREX pipeline fittings including elbows, reducers, tees, caps, return bends, laterals, spacers, adjustable joints, traps, adapters and adapter connections. These are described in Corning Bulletin EA-3 "PYREX brand 'Double-Tough' Glass Pipe and Fittings."

CORNING GLASS WORKS

13 Crystal Street, Corning, New York

Please send me PYREX Shell and Tube Heat Exchanger Bulletin PE-33 ☐; PYREX Pipe and Fittings Bulletin EA-3 ☐.

Name.. Title..........................

Company..

Street..

City.................................. Zone.................. State..........................

Corning means research in Glass

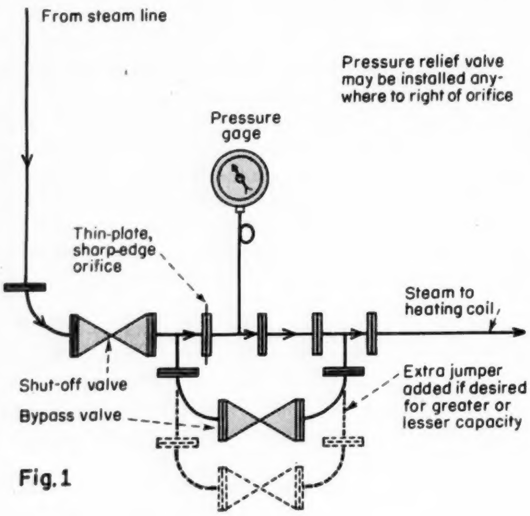


Fig. 1

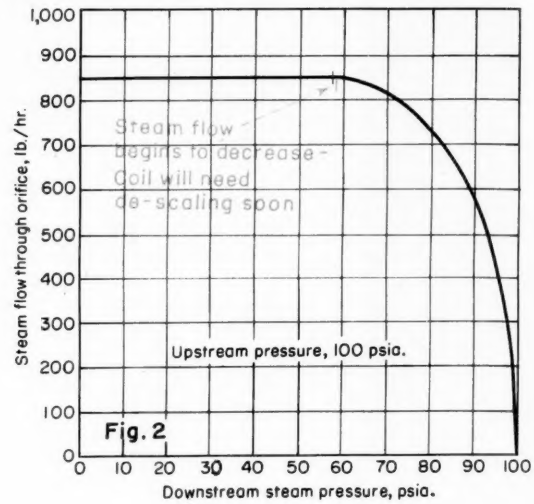


Fig. 2

★ **Winner of December Contest**

Use an Orifice to Control Heat Transfer

In applications where heat transfer surfaces foul you can hold a constant rate of heating without attention.

Harlan How
Equipment Design Consultant, Maitland, Fla.

Use of orifices for flow measurement is a common application, known to everybody. Another type of application, which seems to be known to few people, is to use an orifice without any additional instrumentation (except a pressure gage) to maintain a constant flow. The particular application discussed here (Fig. 1) is one I have used for many years to control the flow of steam to the heating coils of evaporators in cases where the solution being evaporated builds up scale on the heat transfer surface.

Let's consider first what happens in such an evaporator without the orifice control. Assume we are heating a brine containing an inverse-solubility solute such as calcium sulfate. As the evaporation proceeds, an insulating layer of sulfate builds up on the heating coil.

Suppose that initially, with a clean coil, the heat-transfer rate is 1,200 Btu./(hr., sq. ft., °F.) and the temperature difference Δt from steam to boiling solution is 20 F. Thus initial heat transfer is at the rate of 24,000 Btu./(hr., sq. ft.). However, as the scale builds up, U must decrease and Δt must therefore increase correspondingly to hold the same over-all heat transfer rate. Without an orifice in the line, or some other form of controller, the operator must gradually open the steam-line valve and raise the steam-chest pressure to hold $U\Delta t$ constant.

For example, by the time that U has fallen to 600, it will be necessary to raise the steam

---

★ **Winner of January Contest—R. J. Rieke and D. C. Fisher**

Automatic Controller for Impregnation

How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 cash each month to the author of the best short article received that month and accepted for the Plant Notebook.

Each month's winner will be announced in the issue of the second following month, and published the third following month.

$100 Annual Prize—At the end of each year the monthly winners will be rejudged and the year's best winner awarded an additional $100.

How to Enter Contest—Any reader (except McGraw-Hill employees) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable non-winning articles will be published at space rates ($10 min.).

Articles may deal with plant or production "kinks," or novel means of presenting useful data, of interest to chemical engineers. Address Plant Notebook Editor, *Chemical Engineering*, 330 West 42nd St., New York 36, N. Y.

pressure enough to increase its temperature by 20 F., thus raising Δt to 40 F. Obviously it will be difficult if not impossible to do this manually with any degree of accuracy.

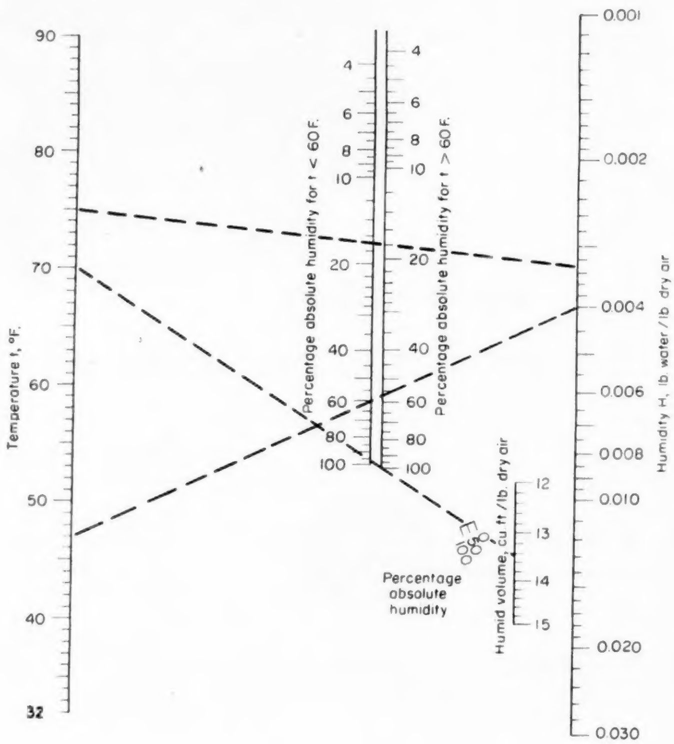
In common with nozzles, orifices have the property of passing a constant weight rate of flow which depends only on the orifice coefficient and diameter, and the upstream pressure P_1—so long as the downstream pressure P_2 is less than the critical, that is, less than 0.58 P_1. Fig. 2 shows how, for a particular orifice, the flow of 100 psia. steam will remain constant at 850 lb./hr. until the downstream pressure reaches 58 psia. Then as the downstream pressure continues to increase, the flow falls off rapidly until it ceases entirely when the up- and downstream pressures become equal.

Fig. 1 shows how this situation can be used advantageously for heating steam control. Steam at a controlled pressure flows to the evaporator steam chest through a thin-plate, sharp-edged orifice provided with a bypass valve and a pressure gage downstream of the orifice. The orifice can be sized conveniently by means of Napier's equation: $W = P_1A/70$, where W is the steam flow in lb./sec., P_1 is the upstream steam pressure in psia., and A is the orifice area, in sq. in. Although other equations such as Grashof's and Rateau's are somewhat more accurate, the Napier formula is accurate enough, and more convenient.

With this arrangement the shut-off valve is opened wide and the orifice will then pass a constant weight of steam depending on the orifice characteristics and the upstream pressure. As the scale builds up the downstream pressure will gradually increase so as to increase Δt just enough to hold $U\Delta t$ constant. This will continue until P_2 has increased to 0.58 P_1, at which point (as shown by the pressure gage) the steam flow will start to decrease as in Fig. 2, and the amount of heat transferred will begin to fall. This of course means decreased production for the evaporator and hence indicates that it is now time to shut down for scale removal.

In explaining the control action of the orifice it has been assumed that all the steam passed can be condensed. This presupposes that the steam coil is equipped with an adequate steam trap for removing condensate and air or other non-condensibles.

The system described will compensate not only for decreased heat transfer due to scale formation. It will also take care of a decreased temperature difference due to increasing boiling point of the liquid as it becomes more concentrated, or due to air in the steam supply to the coil. Within limits it will also take care of variations in evaporator pressure due to fluctuations in the quantity or temperature of the condenser water.



Humidity Nomograph for Low Ranges

D. S. Davis
Professor of Engineering, University of Alabama, Tuscaloosa, Ala.

Conventional natural-scale humidity charts are crowded and difficult to read at low temperatures and low humidities. On such charts interpolation is inconvenient and uncertain at percentages of absolute humidity below 20. No such disadvantages are encountered when one uses the accompanying nomograph, which provides exceptionally open logarithmic scales for humidity and percentage humidity.

The use of the chart, which was constructed by means of standard methods, is illustrated as follows. Air at 47 F. has a percentage absolute humidity of 60. What is the humidity or content of water in 1 lb. of dry air? Connect 47 on the t-scale and 60 on the vertical, lefthand

Inside Story on
POWELL NI-RESIST VALVES

All corrosion-resistant valves may look alike on the outside. But on the inside there can be a big difference -- in the materials used, in design and in production methods. And the inside story on Powell Ni-Resist* Valves features all three factors.

Ni-Resist valves by Powell have far greater corrosion, erosion, heat and wear resistance than ordinary cast iron. Although comparable in strength and physical characteristics to gray iron, and resembling austenitic stainless steel, no other cast metal offers such a unique combination of use properties.

While similar metals are now available, The Wm. Powell Company has selected Ni-Resist, the alloy cast iron developed by The International Nickel Company. Performance records, taken over a period of many years, conclusively prove that Ni-Resist has been used with outstanding results for valves, pumps and other equipment handling corrosive and erosive fluids.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our Ni-Resist Valves as well as our complete line of Powell Quality Valves -- all with Performance Verified.

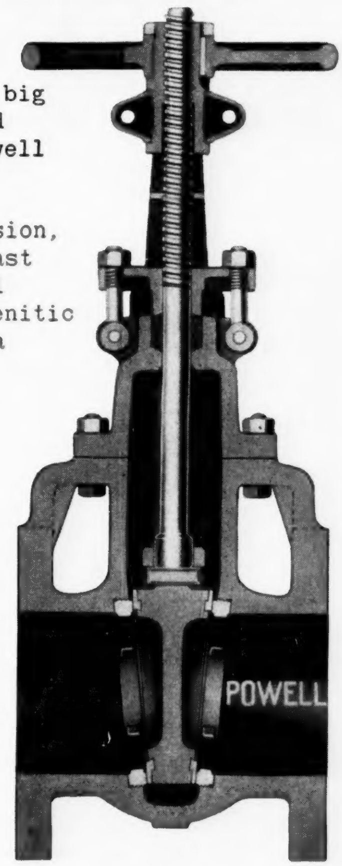


FIG. 2193 (Sectional) -- 2-Piece Yoke O.S. and Y. Gate Valve for 200 Pounds W.O.G.

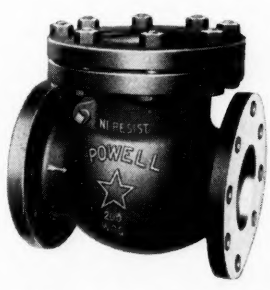


FIG. 2192 -- Large Swing Check Valve for 200 Pounds W.O.G.

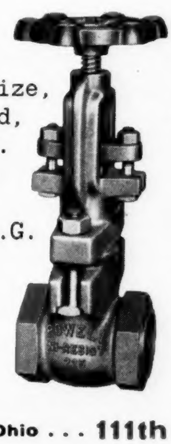


FIG. 2194 -- Small Size, Screwed End, O.S. and Y. Gate Valve for 225 Pounds W.O.G.

**Trademark of The International Nickel Co.*

PERFORMANCE
PV
VERIFIED

The Wm. Powell Company, Cincinnati 22, Ohio . . . 111th YEAR

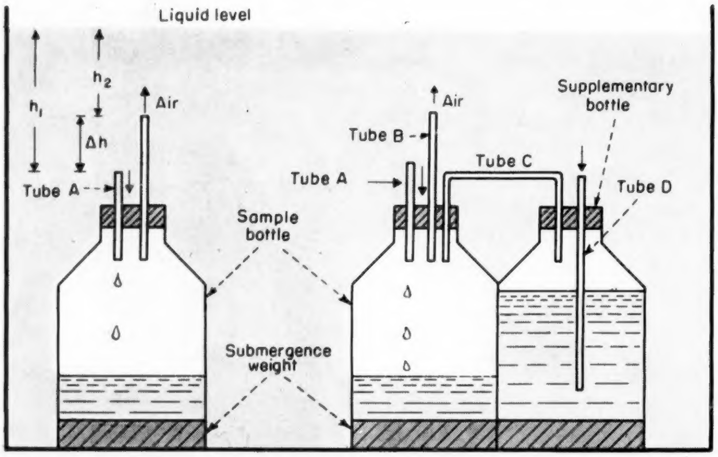
POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES

scale for percentage absolute humidity with a straight line and continue this line to the H-scale where the humidity is read as 0.004 lb. water/lb. dry air.

Air at 75 F. contains 0.0033 lb. water/lb. dry air. What is the percentage absolute humidity? Connect 75 on the t-scale and 0.0033 on the H-scale with a straight line and note that this line intersects the righthand, vertical scale for percentage absolute humidity at 18.

What is the humid volume of air that is 50% saturated at 70 F.? Connect 70 on the t-scale and 50 on the small, slant scale for percentage absolute humidity with a straight line. Continue this line to the humid volume scale where the desired value is read as 13.50 cu. ft./lb. dry air.



Simple Device Takes Uniform Sample

Takashi Goto and Tatsuo Hiraoka
Shimizu Works, Nippon Light Metal Co., Ltd., Miho, Shimizu City, Shizuoka, Japan.

The sketches above show two forms of a simple liquid sampler which takes in a sample of the liquid in which it is submerged, the sampling rate remaining constant until the sample bottle is filled. The single-bottle type at the left serves for most purposes. For very accurate sampling under certain conditions, the two-bottle type is preferred. The sampler has been used successfully in plant work. It requires merely a bottle of suitable size, some capillary tubing, and a weight to submerge the bottle.

Let us first examine the operation of the single-bottle type. When it is first submerged the pressure within Tube A is $h_1\rho + atm.$ and that within Tube B is $h_2\rho + atm.$ Soon the pressure within the bottle will increase, through inflow of liquid, or temperature increase, or both, until the pressure becomes $h_2\rho + atm.$ At that point air will begin to discharge through Tube B and the bottle pressure will remain constant, so that a constant pressure difference of $(h_1 - h_2)\rho$, or $\Delta h\rho$, will exist across Tube A.

Therefore, once this pressure has been attained, the flow rate through Tube A will remain constant and proportional to $(2\Delta h\rho g)^{\frac{1}{2}}$. Here the h-terms are in depth of liquid, atmospheric pressure is measured in the same units, ρ is specific gravity, and g is the gravitational conversion factor.

With a single bottle, the only time the flow rate will not remain constant will be during the initial period while the bottle pressure is increasing from $atm.$ to $atm. + h_2\rho$. Use of a supplementary bottle as in the righthand sketch will prevent this inconsistency. Here Tube D is somewhat larger and it can be put lower than Tube A and B. The liquid first enters the supplementary bottle, raising the pressure rapidly in both bottles until the pressure $atm. + h_2\rho$ is attained. Thereafter the pressure across Tube A will remain constant as before.

The size of supplementary bottle needed can be calculated from the relationship:

$$V_c = V_s\left[\frac{(10 + H\rho)\,(273 + t)}{10\,(273 + t')} - 1\right]$$

where V_c and V_s are respectively the supplementary and sample bottle volumes, H is submergence of Tube A in meters, and t and t' are respectively the temperatures of the air in the bottle before submergence, and of the solution, both in ° C. If V_c comes out negative, no supplementary bottle is required.

The size of Tube A can be determined from the pressure drop and a consideration of the viscosity (or consistency in case of a slurry). The rate of sampling is determined both by the tube size, and by the adjustment of submergence difference Δh of Tubes A and B.

This method of sampling has several advantages. There is no evaporation and no need for thermal insulation. The device is nonmechanical, simple to construct and low in cost. Sampling is continuous and at a constant rate, widely adjustable and suitable for any sample size within the limits of bottle sizes which are available.

Two Methods for Flameproofing Canvas

Paul C. Ziemke
Engineer, Oak Ridge, Tenn.

Plants sometimes need to fireproof canvas for a variety of uses such as vibration isolation in ductwork, draw curtains for storage closets, sun-excluding drapes for large factory windows, and protective curtains for arc welding.

The older method first de-

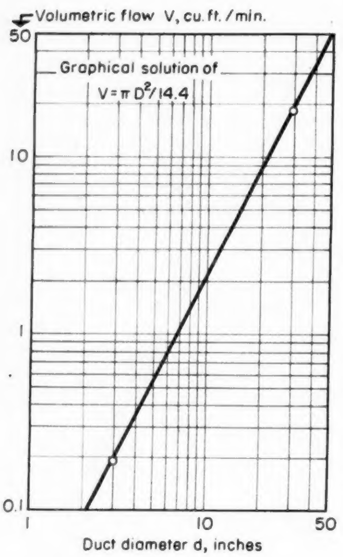
scribed is cheap and easy to apply, but does have the disadvantage of using water-soluble materials which can be partially leached out if sprayed by fire-sprinkler action, or completely leached out if the canvas is laundered.

It consists in soaking the canvas in a mixture consisting of six parts by weight of borax, five parts of boric acid and 100 parts of water. The solution is used cool and the soaking continued long enough to insure thorough impregnation. The canvas is then wrung out lightly and laid flat on a clean surface to dry. This method increases the weighting by 10-12%. If soaking is impractical, brushing or spraying will suffice if the treatment is performed an additional time to bring the weighting up to 10-12%.

The second, newer method was developed by chemists carrying out research for the Army Quartermaster Corps and the U. S. Department of Agriculture. It combines two chemicals previously used separately, and is much superior to previous methods using either singly.

The treatment consists of a mixture of one part of BAP (bromoform allyl phosphate) and two parts of THPC resin solution (tetrakis hydroxy methylyl phosphonium chloride). This is applied to the cloth which is then dried and cured by heating.

The process weighs the canvas about 18% but otherwise changes its fabric properties very little. Flame resistance is little affected by laundering or dry-cleaning. The fabric can be dyed if desired for better appearance.



Straight-Line Plots Solve Equations

Merton Allen
Chemical Engineer, General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

Although engineers are familiar with the use of graph paper to represent technical data, few seem to use this method to solve problems involving repetitive calculations. If the correct type of graph paper is selected—rectangular, logarithmic or semi-logarithmic—certain types of equations will plot as straight lines. In this way repetitive calculations which involve the change of one variable and the calculation of the other can be carried out from a graph by solving for only two conditions and plotting the equation as a straight line through the two known points on the proper type of graph paper. Other values can be quickly picked off.

Typical Relationships Yielding Straight-Line Plots

No.	Relationship	Graph Paper	Plot
1	$Y^a = BX^c$	Logarithmic	Log X vs. log Y
2	$Y^a = B + CX^d$	Logarithmic	Log X vs. log $(Y - B)$
3	$Y^a = Be^{cx}$	Semi-log	X vs. log Y
4	$Y = Ae^{bx} + C$	Semi-log	X vs. log $(Y - C)$
5	$\left\{\begin{matrix} Y = X/(A + BX) \\ X/Y = A + BX \end{matrix}\right\}$	Rectangular	$1/X$ vs. $1/Y$

The tabulation shows several types of relationships which, if plotted as indicated on the proper graph paper, will yield straight lines. Although there are other relationships which can also be plotted as straight lines, their use is generally too long to be of any value in time saving.

As a simple illustration of this method assume we wish to find a large number of volumetric flow rates of a gas with a flow velocity held to 40 fpm., in ducts from 3 to 50 in. I.D. For this example the mathematical relationship would be:

$$V = \frac{v\pi D^2}{4} = \frac{40\ \pi d^2}{4 \times 144} = \frac{\pi d^2}{14.4}$$

where V = volumetric flow rate, cfm.; v = flow velocity, fpm.; and D and d are duct inside diameters, respectively in ft. and in.

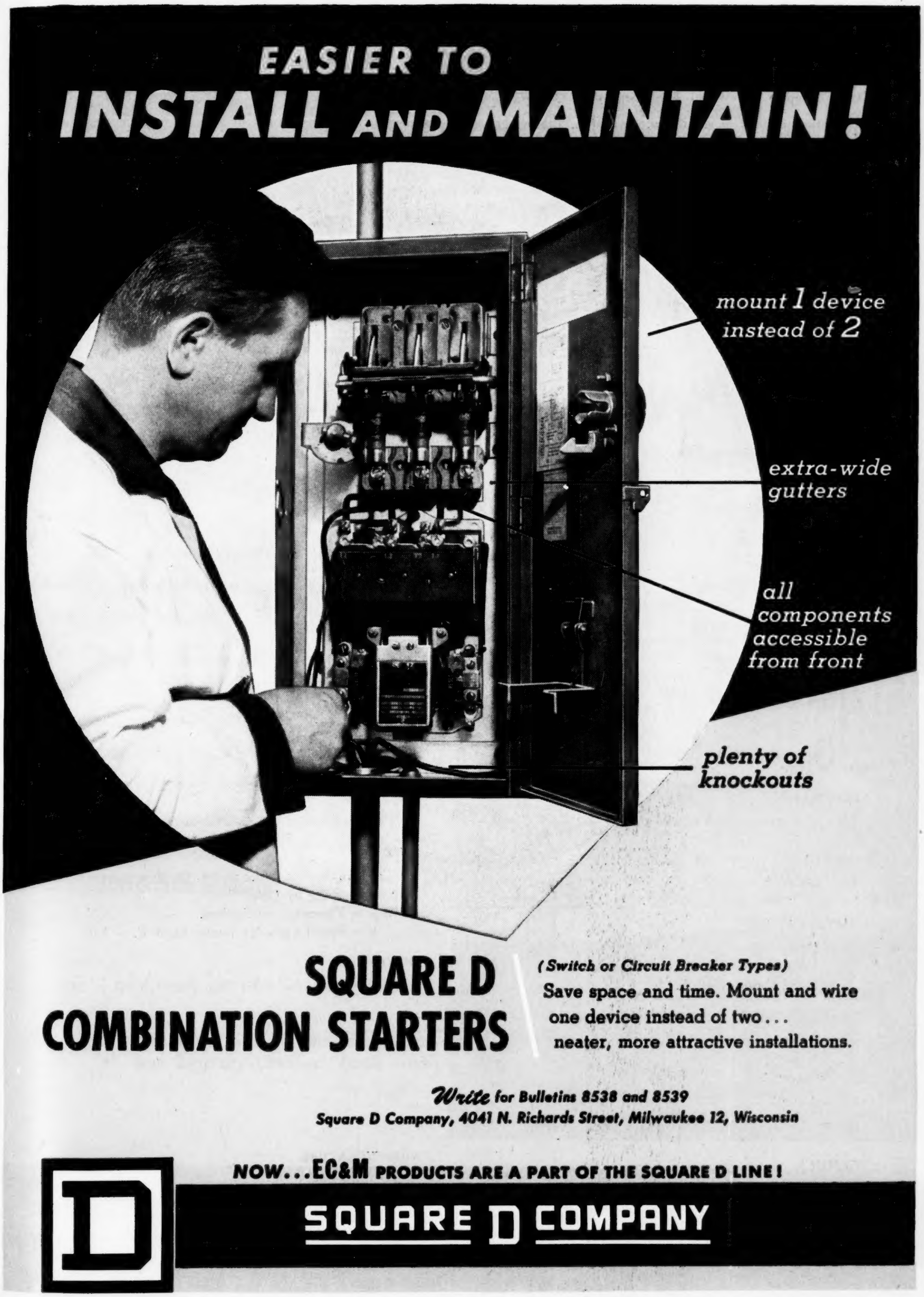
This is in the form $Y^a = BX^c$ where a is unity, B is $\pi/14.4$ and c is 2. If we solve for two conditions: where d is 3 in., then V is 0.196 cfm.; and where d is 30 in., V is 19.6 cfm.

Plotting these values on logarithmic paper as log V vs. log d, we get the straight line shown on the graph, from which any value of V for any value of d can be read.

Other relationships that can be handled with the same type of equation include the orifice formula, $V = Cv(2g\Delta h)^{\frac{1}{2}}$; and the formula for electric energy transformed to heat, $P = I^2R$. An example of an equation of Type (3), $Y^a = Be^{cx}$, is the rate equation $C = C_oe^{Kt}$. There are many others to fit each of the types of equations, too numerous to mention.

If the value of $V = v\ \pi\ D^2/4$ is desired for varying linear velocities v, the plot can be made for v = unity and the results read from the graph and multiplied by the actual linear velocity to arrive at the answer.

It is therefore clear that the introduction of a third variable to a power, such as Z^n, as a multiplier of the righthand side of one of the listed equations does not invalidate the method. Merely plot the relationship at $Z = 1$, and multiply the observed graphical results by the true value of the third variable raised to its power.


EASIER TO
INSTALL AND MAINTAIN!
mount 1 device instead of 2
extra-wide gutters
all components accessible from front
plenty of knockouts
SQUARE D
COMBINATION STARTERS
(Switch or Circuit Breaker Types)
Save space and time. Mount and wire one device instead of two . . . neater, more attractive installations.
Write for Bulletins 8538 and 8539
Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin
NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!
SQUARE D COMPANY

CE Flow File—III

Maxey Brooke, Chemical Engineer, Old Ocean, Tex.

(For author biography see *Chem. Eng.*, Jan. 1957 p. 298.)

8. Water

APPLICATION

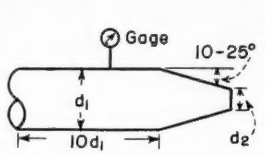
Flow of water through nozzle as illustrated.

FORMULAS

$$q = 440KA\sqrt{H}$$

$$K = \sqrt{\frac{2g}{1 - r^4}}$$

$$r = d_2/d_1$$



NOMENCLATURE

q = Water flow, gpm.
A = Area of nozzle outlet, sq. ft.
g = 32.2 ft./sec.^{2}
d_1 = Diameter of pipe at gage, ft.
d_2 = Diameter of nozzle at outlet, ft.

REFERENCE

API Manual on Disposal of Refinery Wastes, 4th ed., 1949, p. 66.

---

9. Water

APPLICATION

Flow of water in partially filled pipes.

FORMULAS

$$Q = 9.43D^{2.56}K^{1.84}$$

$$q = 7.3d^{2.56}K^{1.84}$$

LIMITATIONS

The formula was derived specifically for pipes between 1 and 6 in. in diameter. The value of K should be between 0.2 and 0.6.

NOMENCLATURE

Q = Flow, cfs.
q = Flow, gpm.
D = Internal diameter of pipe, ft.
d = Internal diameter of pipe, in.
K = Decimal fraction of vertical diameter under water.

REFERENCE

Greve, Purdue Univ. Bull. 32, 1928.
Ind. Eng. Chem. 34, 52, 1942.

---

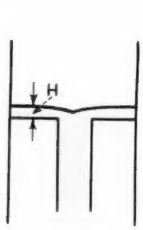
10. Water

APPLICATION

Flow of water through downspouts.

FORMULA

$$Q = 3.0LH^{1.4}$$



NOMENCLATURE

Q = Overflow, cfs.
L = Perimeter of crest, ft.
H = Head above crest, ft.

LIMITATIONS

For heads up to 1/5 the diameter of the crest curve.

NOTE

For liquids other than water, the flow can be estimated by multiplying by $(\mu/s)^{0.02}$
where μ = Viscosity, centipoises.
s = Specific gravity (water at 60 F. = 1.0)

REFERENCE

Gouley, *Proc. Inst. Civil Eng. Part 2*, 1910, p. 297.

---

11. Water

APPLICATION

Flow of water through corrugated iron culverts.

FORMULA

$$Q = A\sqrt{gH}\,(1 + 0.16d^{0.6} + 0.106L/d^{1.2})^{-1/2}$$

REFERENCE

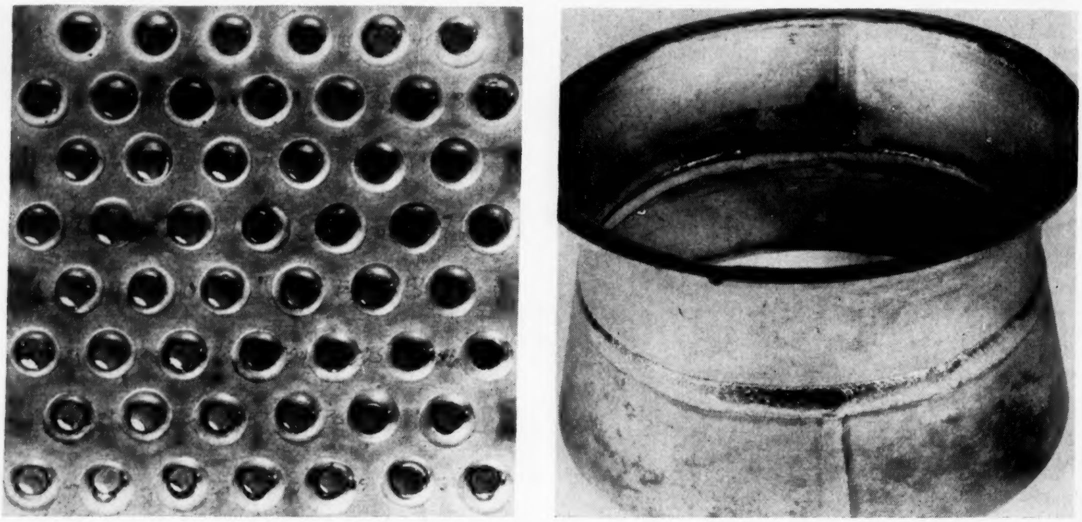
D. F. Yarnell, F. A. Nagler and S. M. Woodward. Univ. of Iowa Studies in Engineering, 1926.

NOMENCLATURE

Q = Flow, cfs.
L = Length of culvert, ft. (24 to 36 ft.)
d = Diameter of culvert, ft. (1 to 4 ft.)
H = Loss of head, ft. of water.
g = 32.2 ft./sec.^{2}
A = Cross-section area of culvert, sq. ft.

PRACTICE . . .

CORROSION FORUM EDITED BY R. B. NORDEN



HEAT EXCHANGERS (Battelle Memorial Inst.) and nozzles point way for equipment made of Mo-base alloys.

Molybdenum Combats High Temperature

Rapid advances in technology now make molybdenum available in many forms and sizes. This high-melting point metal is superior to many superalloys at 2,000 F.

A significant development, coming out of the current intensive work on high-temperature-containing materials, has been the improvement in properties and availability of molybdenum metal and molybdenum-base alloys (*see p.* 237).

Now, one of the advantages to process engineers of molybdenum over ceramics, cermets and some superalloys is the variety of forms and sizes available. Sheets, drawn shapes, machined parts, forgings, are produced on a production basis.

Molybdenum is of interest as a high-temperature material of construction because of its high melting point, high strength and stiffness at elevated temperatures, and good thermal and electrical characteristics.

Molybdenum's melting point of 4,750 F. is about 1,800 F. above that of the common high-temperature alloys and is exceeded only by tungsten and tantalum among the more readily available metals (*see table*).

Modulus of elasticity is approximately 45,000,000 psi. at room temperature — about the highest of all commercially available metals. This modulus is little effected by temperature. At 1,600 F. it is still about one-third higher than steel at room temperature. A comparison of the modulus density ratio for several commercial alloys shows molybdenum to be outstanding (see curves from Marquardt Aircraft Co. data).

Thermal conductivity of molybdenum is several times as great as the conductivity of the usual high-temperature alloys. Together with low specific heat, this permits it to be rapidly heated or cooled with lower resultant thermal stresses.

Coefficient of thermal expansion is one-third to one-half that of most steels. When operating at elevated temperatures this insures dimensional stability and less danger of cracking due to temperature gradients.

Electrical conductivity is relatively high (about one-third) that of copper, thus permitting its use for many electrical applications.

Absorption cross section for thermal neutrons is relatively low; only carbon, beryllium, zirconium, silicon and columbium of the high melting-point elements have a lower cross section.

The small amounts of alloying elements added in the present molybdenum-base alloys apparently have little effect on physical properties. They do, of course, have a marked effect on mechanical properties.

Mechanical Properties

Mechanical properties of molybdenum are determined, in the main, by the amount of work performed on the material below its recrystallization tempera-

Physical Properties of Molybdenum[a]

Atomic no.	42
Atomic weight	95.95
Melting Pt., F	4,750
Density (68 F.), lb./cu. in	0.369
Specific heat (70 F.), Btu./lb./F	0.061
Thermal conductivity, Btu./hr./sq. ft./F.	
70 F	72
1,650 F	62
Coefficient of expansion/F.	
68–212 F	3.16×10^{-6}
68–1,832 F	3.37×10^{-6}
Modulus of elasticity in tension, psi.	
80 F	46.0×10^{6}
1,600 F	39.9×10^{6}
Modulus of rigidity, psi.	
80 F	17.4×10^{6}
1,600 F	15.1×10^{6}

[a] Unalloyed molybdenum and the alloys now available have about the same physical properties.

ture, as neither the pure metal or any of its commercial alloys is heat-treatable.

Properties of molybdenum and its alloys are very sensitive to several factors including amount of mechanical deformation, thermal treatment, strain rate, and purity. Careful control of processing is necessary to get desired properties in the finished material.

Increasing amounts of mechanical deformation below the recrystallization temperature result in higher strength and hardness as measured at room temperature. The strength of the sintered or cast ingot is quite low—on the order of 45,000-70,000 psi.—but this may be increased to over 250,000 psi. by drawing to a fine wire of the order of 0.001-in. to 0.002-in. diameter.

Hardness of the unalloyed cast ingot is about 180 Vickers. By severe working, the hardness of bars can be raised to about 250 Vickers.

For the 0.5% titanium-molybdenum alloy the ingot is very little harder than the unalloyed ingot. But the worked material may have a hardness as high as 300 Vickers, as measured on $\frac{5}{8}$-in. diameter bars. The hot hardness, measured at 1,600 F., of the unalloyed bar would be about 120, as against 180 for the alloy containing 0.5% titanium.

When molybdenum is subjected to temperatures at or above its recrystallization temperature for a period of time long enough to cause recrystallization, strength at room and elevated temperatures decreases markedly. For this reason it is essential in high temperature applications that the recrystallization temperatures be raised as high as possible. Then the metal may be used at the maximum temperature without recrystallization and resulting drop in strength.

Small additions of alloying elements have been successful in raising the recrystallization temperature as much as several hundred degrees F. For 1-in. rounds, previously given 91% reduction in area by rolling, the minimum temperature for complete recrystallization in one hour is raised from 2,200 F. for unalloyed molybdenum to 2,600 F. for the 0.5% titanium-molybdenum alloy. This permits operation of the alloy at temperatures several hundred degrees higher than with pure molybdenum, without danger of recrystallization.

Transition Temperatures

Molybdenum undergoes a change from ductile to brittle behavior as the temperature of testing is lowered. The "transition" temperature at which this occurs depends on several factors and especially on the strain rate, purity, fabrication methods used and stress system.

This transition temperature for molybdenum is near room temperature when measured by the tensile test and is usually in the range of 450-900 F. when measured by the impact test. Alloying in some cases causes a decrease in the transition temperature, in others an increase.

Creep-Rupture Superiority

It is in the range of temperatures above 1,600 F. that molybdenum's superiority to the common high-temperature alloys becomes outstanding. At 1,800 F. the 100-hr. rupture strength of unalloyed molybdenum, in the stress relieved condition, is about 28,000 psi., and in the recrystallized condition it is about 12,000 psi.

For 0.5% titanium-molybdenum the corresponding strength values are 53,000 psi. and 28,000 psi., or more than double the values for unalloyed material. Most of the superalloys in use today have a 100-hr. rupture strength of 10,000 psi. or less at the same temperature.

Chemical Properties

Molybdenum is quite resistant to several of the common chemical reagents including most caustic solutions and hydrochloric, sulfuric, and hydrofluoric acids under certain conditions of temperature and concentration. It is rapidly attacked by oxidizing acids such as nitric acid and aqua regia, by molten oxidizing salts such as potassium nitrate, and by fused alkalies.

Molybdenum is very resistant to many of the liquid metals such as potassium, sodium, bismuth, lithium, magnesium and mercury, even at elevated temperatures.

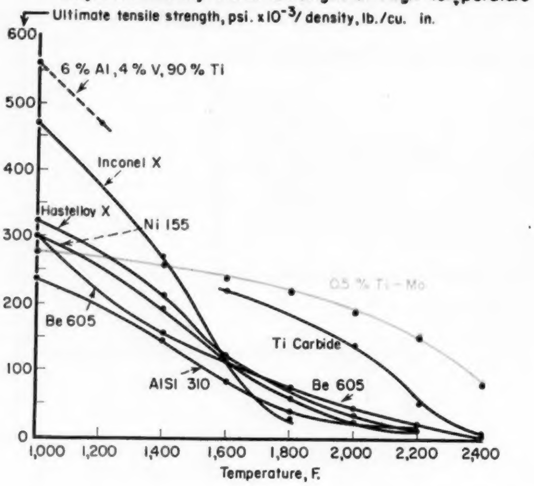
Water vapor, sulfur dioxide, nitrous and nitric oxides have an oxidizing action on molybdenum at elevated temperatures. But it is relatively inert to carbon dioxide, nitrogen, or synthetic ammonia at temperatures up to about 2,000 F.

Commercial Availability

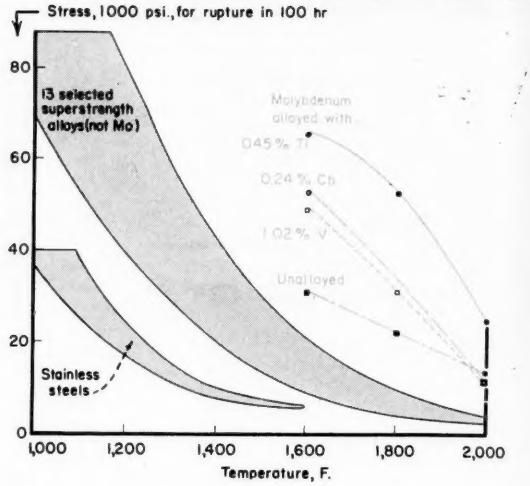
Although all of the problems in connection with the fabrication of molybdenum have not been solved, fabricated parts are now available, subject to some limitations as to size and complexity.

Spinnings—Ten to fifteen years ago few molybdenum spin-

Molybdenum Alloy Holds Strength at High Temperature



Molybdenum Alloys Show Good High-Temp. Strength



ings were made from sheet more than 0.030-in. thick or 6-in. wide, and the ratio of length to diameter rarely exceeded 1 to 1. Spinnings have recently been made from sheets as large as 0.090 in. x 20 in. x 20 in. and cylinders with a length to diameter ratio of 5 to 1 have been supplied.

The recently developed hydraulic spinning processes, such as Floturning* and Hydrospinning†, have demonstrated that it is possible to form molybdenum sheet as heavy as $\frac{3}{16}$-in. thick by these methods.

Drawn Shapes—Although deep drawn parts are normally fabricated from sheet in the range of 0.005-in. to 0.020-in. thick, some parts are now drawn from sheet as heavy as $\frac{1}{16}$-in. to $\frac{1}{8}$-in. thick. Recently, deep drawn seamless tubing has been produced in diameters between $\frac{1}{8}$ in. and 1 in. with wall thicknesses of 0.005 in. to 0.040 in. The length of tube increases with the diameter, reaching a maximum of 4½ ft. for the $\frac{7}{8}$-in. and 1-in. dia. tubes.

Machined Parts—Fifteen years ago molybdenum was machined only with difficulty. Today, almost all machining operations can be carried out without difficulty. And there are now several companies in this country who specialize in supplying precision machined parts from molybdenum.

Forgings—Forgings have proved economical on several applications in the electronic tube industry where the quantities required were relatively large. Less material is required and machining costs are considerably reduced when forgings can be used in place of machining. Where large diameter pieces are required, upset forging is often the only process that will work.

Extrusions—All arc-cast ingots are extruded as solid bars after casting and before further processing. Tubing may also be produced by this process and by other extrusion methods. Tubes as large as 4-in. O.D. x 40-in. long have been extruded experimentally. But most commercially extruded tubes are in the range of ½-in. to $\frac{5}{64}$-in. O.D. x 12-in. to 60-in. long.

Welded Parts—Assemblies of molybdenum parts for electronic tubes have been made for many years by electric spot welding. Molybdenum tubing made by the arc-welding of formed sheet is available in sizes up to about 3-in. or 4-in. dia. depending on the wall thickness and length required. Molybdenum boats for use in firing small parts at high temperatures in protective atmospheres are also prepared by welding.

Riveted Parts—Molybdenum rivets are available commercially in a variety of sizes. Small diameter rivets in the range of 0.040-in. to 0.080-in. diameter are commonly used in the electronic tube industry and are made on automatic cold-heading machines. Rivets for joining heavy molybdenum assemblies are normally turned in a lathe from swaged rod up to about 1-in. in diameter. Complete riveted assemblies can be supplied by several fabricators.

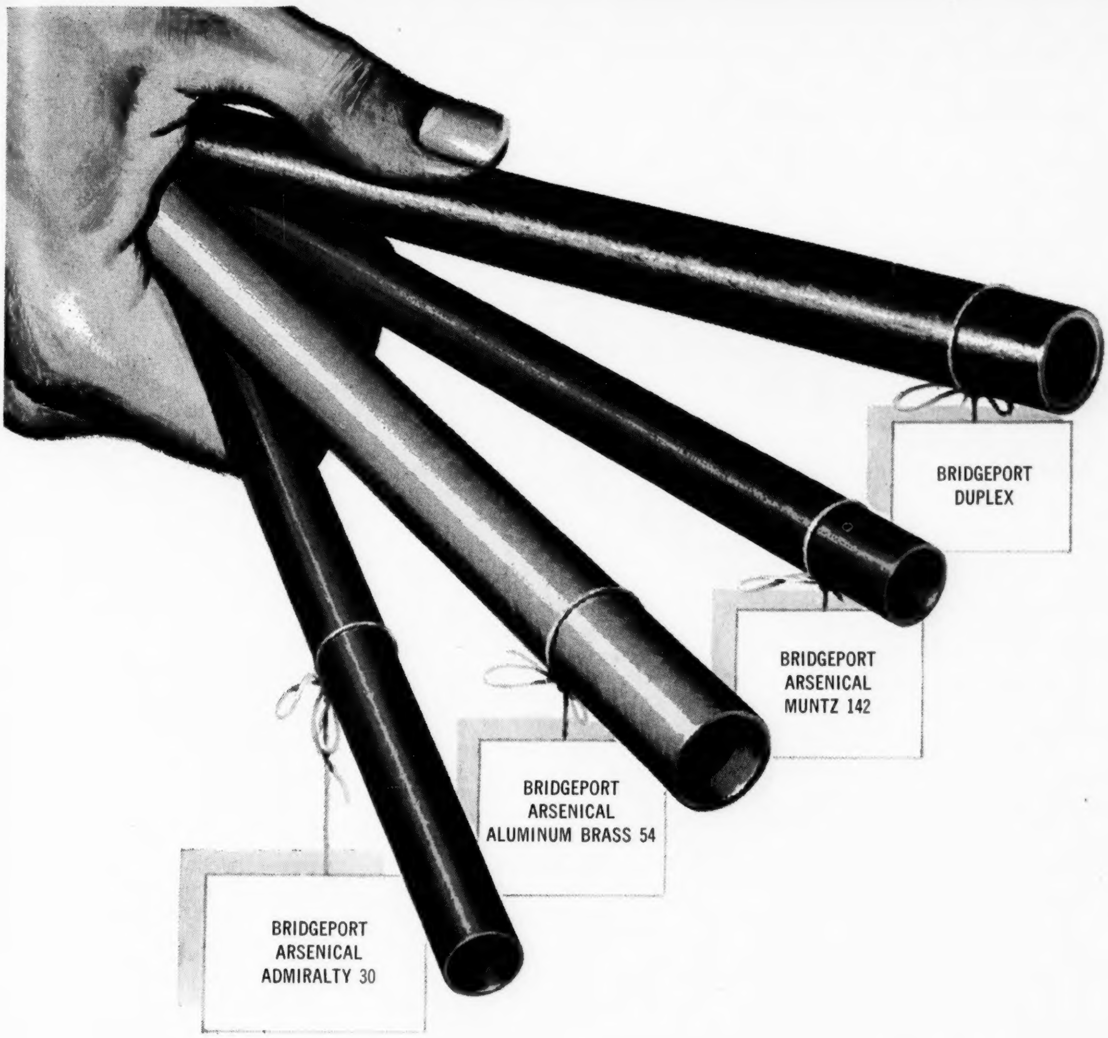
Brazed Parts — Many brazed assemblies involving molybdenum are now supplied to industry. These include molybdenum to molybdenum brazes, molybdenum to copper or copper alloys, and molybdenum to tungsten. The electronic tube and welding electrode industries are important users of this type of assembly.

Metallizing

Molybdenum wire when sprayed through a metallizing gun using an oxy-acetylene flame has the property of bonding perfectly to steel, Monel, nickel, cast iron, magnesium and most aluminum alloys. In addition it provides an excellent surface for subsequent sprayed coatings.

Originally it was recommended primarily as a bonding-coat material between the object

* Lodge & Shipley Co.
† Cincinnati Milling Machine Co.



4 Ways to Lick Sulfide Corrosion In Your Heat Exchangers

Take your choice! You'll find all four of the tubes illustrated ideal for process condensers and exchangers handling heavy concentrations of hydrogen sulfides.

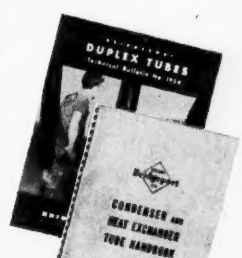
Arsenical Admiralty has established excellent performance records in refineries and processing plants handling low sulfur petroleum products and where fresh or saline cooling water of low to moderate velocity is used.

Arsenical Aluminum Brass is generally used where sea water is the coolant and where water velocities are high.

Arsenical Muntz, while having the same corrosion resistance to salt or fresh water as Admiralty, is resistant to the action of sulfides.

Duplex Tubes offer the advantage of a combination of metals to meet different corrosive attacks on both the product side and on the cooling water side. For instance, on high-stage gas condensers handling wet gas high in hydrogen sulfide and containing ammonia, low-carbon steel/Admiralty Duplex Tubes have given unusually long service in most installations.

Whatever your choice, whatever your tube problem, it will pay you to get in touch with Bridgeport. Our long years of experience in the manufacture and application of condenser and exchanger tubing will save you time, money and trouble. Call your nearest Bridgeport Office today.



For full details, send for copies of Condenser Tube Handbook and Duplex Tube Manual.

BRIDGEPORT BRASS

Bridgeport Brass Company, Bridgeport 2, Conn. • Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

Size Ranges for Commercial Molybdenum

Form	Powder Metallurgy Method	Arc-Cast Method
Machined ingot	To 36 sq. in. and 500 lb.	To 8 3/8-in. dia. and 800 lb.
Extruded bars	....	To 5 3/4-in. dia. and 300 lb.
Rolled bars	1 to 2-in. dia. and to 30 lb.	1/2 to 3 1/2-in. dia. and 250 lb.
Swaged bars	1/8 to 1 1/4-in. dia.	1/8 to 5/8-in. dia.
Ground bars	0.030 to 1 3/4-in. and 25 lb.	0.030 to 3-in. dia. and 100 lb.
Drawn wire	0.0015 to 1/4-in. dia.	0.0015 to 1/4-in. dia.
Heavy plate	1/4 to 1 1/4-in. thick and 50 lb.	1/4 to 1 1/4-in. thick and 150 lb.
Sheet	0.0005 to 1/4-in. thick, 1/16 to 16-in. wide	0.0005 to 1/4-in. thick 1/16 to 36-in. wide.

to be metallized and a sprayed top coating of another metal. But many other new applications involving the use of this coating alone on wearing surfaces have been developed.

It was found that sprayed molybdenum showed very good resistance to wear when running against bronzes. And the life of the bronze mating surfaces is greatly increased. Another application is in abrasive wear such as forming dies, mandrels, and pulleys where shock or impact is not excessive. The use of sprayed molybdenum to salvage machine parts that have been rejected because of errors in machining has become an important application.

Some Applications of Mo

Besides its use in jet-engines and electronic parts, high-temperature furnaces—employing molybdenum resistance wire in the range of 0.030-in. to 0.060-in. diameter as the heating element—have been used to obtain temperatures in the range of 2,500-3,100 F. The use of large rod-type elements in furnace construction, however, is a recent development. Rods in the range of ¼-in. to ½-in. diameter in either straight lengths or formed into various designs, are now common. Radiation shields made from 0.005-in. to 0.010-in. thick molybdenum sheet are now used to cut down radiation losses in high-temperature furnaces.

Susceptors for high frequency induction heating to elevated temperatures are often made from molybdenum sheet or tubing. Alundum furnace muffles which are to be subjected to heavy furnace loads at elevated temperatures are often provided with molybdenum tracks or skids to prevent excessive wear of the muffle bottom. Very large high temperature furnaces are in use which have the roof of the hot section made from heavy plates of molybdenum. This prevents insulation or other foreign material from falling into the heated zone and contaminating the product.

Major Disadvantage of Molybdenum

Despite its high melting point molybdenum oxidizes rapidly at temperatures above 1,000 F. to complete disintegration. This is a major obstacle to widespread use of molybdenum and its alloys for high temperature service.

The volatility of molybdenum trioxide—an end product of the oxidation reaction prevents the formation of a self-protective oxide.

In slowly flowing air at 1,800 F. the surface of molybdenum recedes at 0.02 to 0.05 in./hr. The maximum permissible rate for a iron-chromium-nickel alloy is about 0.1 in./yr. At 1,750 F. in slowly flowing air, oxidation rates of 0.58 to 0.92 grams/sq.cm./hr. are typical for molybdenum. Armco iron and SAE 1025 steel oxidize at the same temperature at a rate of 0.070 and 0.049 grams/sq.cm./hr. respectively.

Its evident that uncoated molybdenum is completely useless as a material of construction in oxidizing atmospheres above 1,000 F. However in oxygen-deficient atmospheres, molybdenum is satisfactory for many applications (heat - treating equipment, furnace sections).

Coating Techniques

So far no molybdenum-base alloys have been developed with satisfactory oxidation resistance. However, a number of good coatings for molybdenum are available.

A most promising ceramic coating consists of a chromium-frit type which is applied as a slip and fired at 2,600 F. in an inert atmosphere. Another type consists of zirconium oxide or zirconium silicate bonded with a zirconate of calcium, magnesium or barium.

Molybdenum disilicide coatings applied either by vapor deposition or liquid treatments is a coating closely related to the ceramics.

Ceramic or silicide coatings are only useful where service conditions do not involve severe thermal shock or impact. They protect molybdenum up to temperatures of around 1,800 F.

Cladding is another important method for oxidation protection. Most oxidation-resistant metals

How to Make Molybdenum Parts

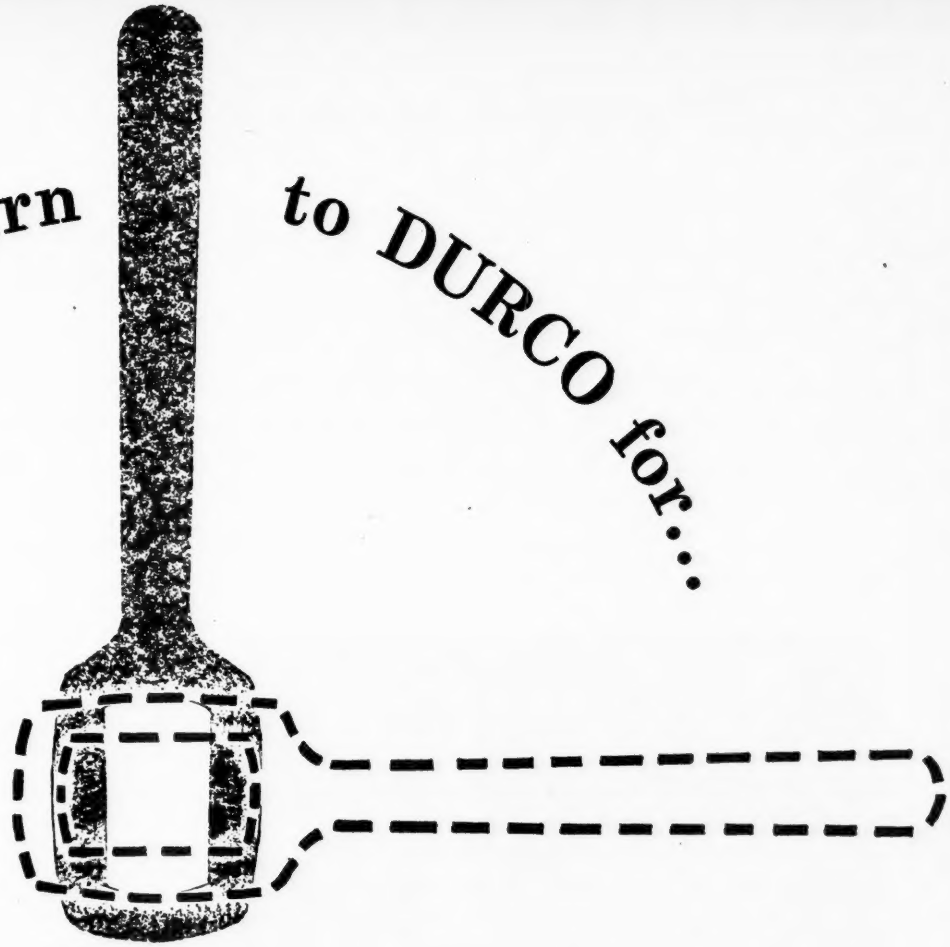
There are two commercial methods now in use for producing molybdenum parts: powder metallurgy and arc-cast.

The powder metallurgy method consists of compacting molybdenum powder, with a press, into bars or ingots. These are sintered by resistance heating in a hydrogen atmosphere at 4,000 F. Sintered ingots are further processed by hot rolling or swaging (forging).

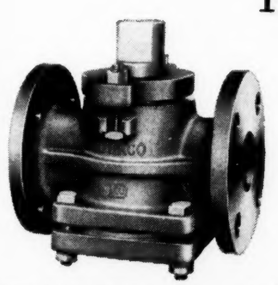
In the arc-cast method molybdenum powder is automatically compacted into wafers or disks. These form a continuous consumable electrode which melts in an alternating current arc, produced in copper molds under vacuum.

Arc-casting lends itself readily to large-scale production of ingots, while powder metallurgy is limited to small parts.

Turn to DURCO for...



Industry's best chemical service valves

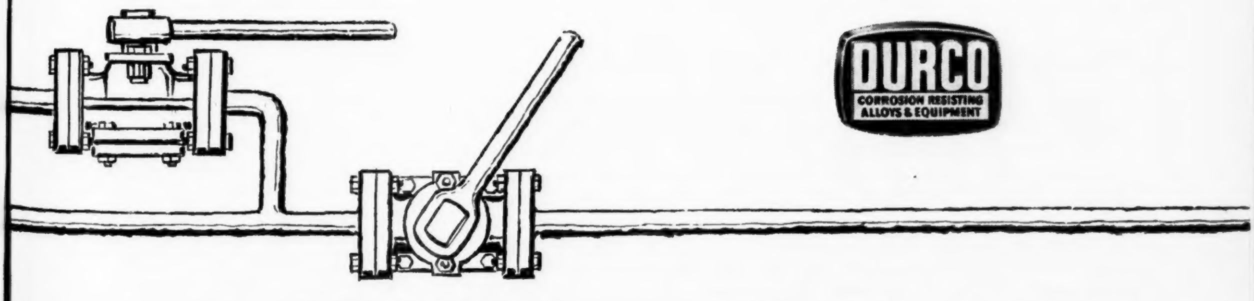


Durco Type F valves are available in 150# and 300# design, as well as three-way. Complete details in Durco Bulletin V/4b.

Durco Type F valves with Teflon sleeves have been proven in thousands of industry's toughest applications to be trouble-free, maintenance-free, and dependable.

Turn to the Durco Type F valve for non-sticking, non-lubricated, economical operation. For long life when handling severe corrosives, get Durco Type F valves. Available in a wide range of alloys in sizes to 3".

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT



The DURIRON Company, Inc. / Dayton, Ohio

Branch Offices: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Detroit, Houston, Knoxville, Los Angeles, New York, Philadelphia, and Pittsburgh

and alloys may be clad to molybdenum by the standard roll method.

Recent development work on cladding has concentrated in the range of 3 to 7 mils thickness. Unalloyed nickel and high (92%) nickel alloys have given excellent protection.

Another coating method with much promise is metal spraying. Two types of alloys—aluminum-chromium-silicon and nickel-boron—are very effective for protection up to 1,800 F. The spray coat is applied with commercially available spray guns. At the present time spray coatings are the most promising method yet developed for protecting molybdenum.

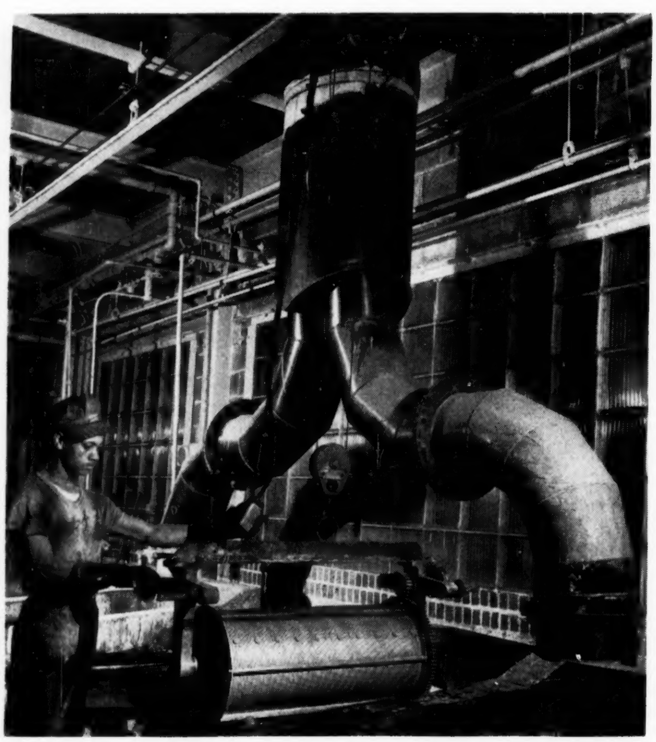
Other techniques under investigation include electroplating, chromizing and diffusion coatings.

Future Applications

The development of new molybdenum-base alloys under the sponsorship of the Office of Naval Research is certain to result in many new uses for these materials within the next few years. Many of these potential applications are already in the research or development phase, while several others are under consideration by interested companies:

- In the glass industry for new items such as feeding devices and molds.
- In the metal working field for pumping molten metals, die casting of brass and other high melting-point alloys, piercing and extrusion of various metals, and cutting tools.
- In the chemical and nuclear energy fields for heat exchangers, process piping, corrosion-resistant applications, and structural parts.
- In the aircraft and missile field, honeycomb structures produced from thin molybdenum sheet may prove advantageous. Such items as guide vanes, skins and nose cones also appear to be promising applications for these alloys.
- In the high-temperature engine field, not only for parts for jet engines where oxidation is a problem, but also for other engine designs.

This report is based on two papers recently delivered in Detroit at an Office of Naval Research sponsored symposium on the technology of molybdenum and its alloys. The two papers were "Properties and Applications of Commercial Molybdenum and Molybdenum Alloys" by R. R. Freeman of Climax Molybdenum and "The Protection of Molybdenum Against High Temperature Oxidation" by J. J. Harwood of ONR.



Polyethylene Fights Hydrochloric Acid Vapors

Vapors from a 50% muriatic acid solution are handled in a polyethylene ventilating system at Parker Rust-Proof, Cleveland, Ohio.

The acid is used for descaling metal prior to rust-proofing. Acid vaporizes when metal parts are dipped into the acid—creating a difficult corrosion problem in the metal fume hoods and ducts previously used.

Fabricated and installed by American Agile Corp., Maple Heights, Ohio, the polyethylene system has an expected life of 10-15 years.

Economical Handling Of Titanium Sponge

When tonnage demand increased sharply in 1955, officials of Rem-Cru Titanium, Midland, Pa., decided to install a materials handling system involving hermetically sealed aluminum bins.

The system is used for transporting titanium sponge—a gravel-like material—which Rem-Cru buys and converts to titanium metal products.

Starting with 60, there are now 125 bins (each with a 5,000 lb. capacity) in service at Rem-Cru, on lease from Tote Systems Inc., Beatrice, Neb.

Rem-Cru estimates the first 60 bins saved $25,000/yr. in labor, production delays and container costs.

Chemical Engineering

People

MARCH 1957

Department Index

when should you pay $13.00* a pound for TITANIUM?

The answer is *when its cost/life ratio makes titanium less costly than other metals*—as it often does. Look at it this way . . .

More Metal Per Pound—Titanium weighs only 56% as much as steel of the same strength. Where 50 pounds of steel is needed—28 pounds of titanium will do the job.

It's Final Cost That Counts—Fabricating takes the lion's share of production costs on most jobs. Considering material and fabricating costs together usually whittles down the titanium price differential to 2 or 3 to 1. And, most important . . .

Titanium Outlasts Most Metals—even those generally considered 'corrosion-resistant,' by 10, 20, even 50 times or more.

Added together, these facts often make titanium the most inexpensive material you can use. And only titanium can provide its exceptional combination of *light-weight, high-strength*, and *resistance to corrosion*. Ask a REM-CRU engineer to give you complete details about what titanium can do for you.

**The actual cost of titanium mill products varies with the grade, size and quantity ordered. The $13.00 figure is representative of today's prices for items used in commercial applications.*

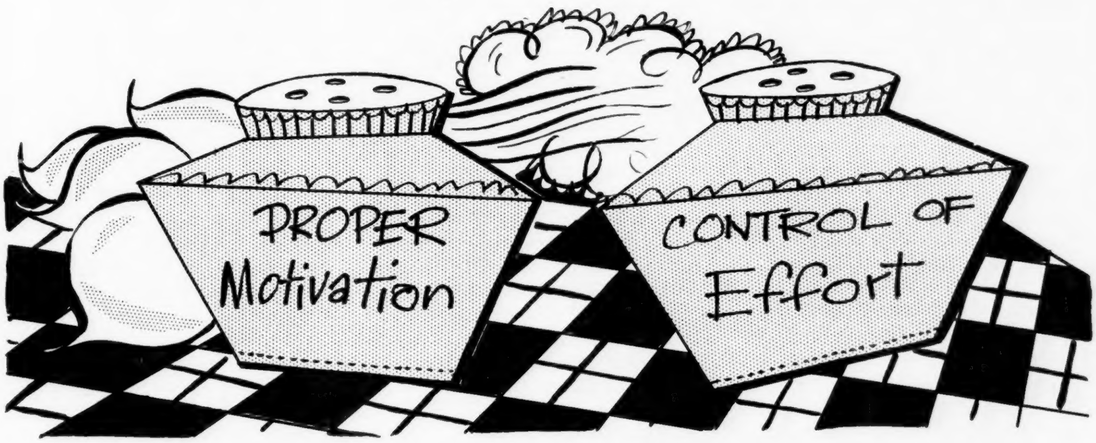
Write Dept. C-3 for the Rem-Cru Review—a free periodical presenting the latest data on titanium.

REM-CRU TITANIUM

World's Most Versatile Metal

MIDLAND, PENNSYLVANIA

Sales Offices: 3338 South Malt Avenue, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y.



TWO VITAL INGREDIENTS WILL SHARPEN YOUR . . .

Recipe for More Successful Managing

Proper motivation and control of engineering effort result from management attention to the work climate. Here's a universal recipe for success.

Robert S. Shane, Westinghouse Electric Corp., Pittsburgh, Pa.

In great measure, the success of any company depends upon the day-by-day performance of its executives and professional people at every level. And, in turn, the success of any manager depends, in great measure, on his ability to blend into the performance of his subordinates the two essential ingredients labeled *proper motivation* and *control of effort.*

The essence of good management, the job of blending these ingredients into all phases of the subordinate's efforts is also a major problem with most managers. Pious exhortations from top management, preoccupation with the numerous fads of personnel administration and even the fear of discharge or the promise of promotion or a salary raise are far from effective solutions to this basic management problem.

ROBERT S. SHANE is manager, chemistry and ceramics section, reactor engineering department in Westinghouse's commercial atomic power activities.

Observation and experience over a period of more than 20 years indicate that use of the techniques described here result in a consistently high output of top quality work. Though they have been developed primarily as an approach to handling people in an engineering division, I believe that the basic suggestions apply to any manager-group relationship.

There is no great novelty in these ideas, but when they are used persistently, desirable professional men invariably respond with a maximum effort that produces outstanding results.

Be Proud of Your Firm

First step for the manager interested in developing a well motivated, highly productive group is to instill in its members a feeling of pride in the achievements of the company as a whole.

As an employer, each successful company has its distinctive attractive traits. If your firm doesn't and if it shows no inclination to acquire such traits, you might be well advised to seek one that does. The job of managing is difficult enough without putting yourself under an additional handicap. But normally, an efficient manager will recognize these traits, present them tactfully and persuasively when hiring people and refer to them frequently in his day-by-day contacts with all his people.

What might be called "managerial evangelism" should be part of every job interview. Each applicant, or prospective applicant, should be sold on the company even before his qualifications are examined and regardless of whether a job offer is made or not. First step in acquiring a well motivated employee, this practice also helps influence people who aren't hired

to regard the firm and its products favorably.

Managerial evangelism is a never-ending job, since each employee must remain convinced that he is an integral part of a worthwhile organization. Periodic reviews of personnel performance present an excellent opportunity for this. And, beyond this, the superior's esteem for the company, mirrored in every facet of his duties, is likely the company's most effective tool for selling itself to its employees.

Inspire Pride in the Group

Pride in the company must be coupled with pride in the group. Through praise of the achievements of group effort, judicious use of comparisons and a soft-pedalling of the manager's role in group achievements, this pride can be built into a unifying force that often leads the group to extraordinary performance.

While original thoughts should always be credited to the individual, special skills and knowledge of the various members of the group must be freely shared with all other members. All members should know that they are expected to cooperate with all others and the doctrine that personal achievement is rooted in group achievement should be strongly urged at every opportunity.

This doctrine applies to the manager, too. His job exists, in this view, solely to make work and achievement easier for his men. He, too, cannot succeed except as members of the group succeed. He cannot be promoted except when there are available men whom he has developed into candidates for his position.

Building Self-Esteem

Instilling a feeling of personal achievement is the final step toward proper motivation. Enforcing high standards of performance, helping the subordinate meet those standards and giving him credit for his achievements comprise the only sound way of building the subordinate's pride in himself and his job. Gimmicks won't do.

One procedure that has been found to be excellent for this purpose is to have the individual make frequent, regular, oral reports to the group. In a regularly scheduled group conference, each member of the group briefly describes his progress on a project, tells of his difficulties and indicates his next steps. Open to suggestions on how to better achieve his objectives, he is also open to judicious public praise for his efforts.

In addition, these discussions lead to a feeling of belonging on the part of each group member as he supports and is supported by other members of the group. And more than once these informal discussions will stimulate new and useful ideas and unveil new approaches to problems.

Incidentally, it may be desirable to have one member of the group take notes on these discussions, circulate them for editing, then have them typed and retained as a progress report. These can be very helpful if top management makes an unexpected request for a status report.

Use Written Reports, Too

The manager should require a regular written progress report on a definite date, usually the last working day of the month. In addition to forcing the individual to review his progress and problems and record concepts, ideas and information in a permanent form, these reports record, for suitable credit, his accomplishments. They form a record of personal achievement in the professional man's own words and are readily available for periodic personnel evaluation conferences.

Recognition of a good job should not be delayed. It can be given when monthly reports come in, at group meetings or on the completion of a job. The superior himself has a real stake in making sure that his men receive proper credit for their achievements as quickly and as often as possible, since he derives at least internal credit whenever one of his group is recognized for an outstanding job.

Controlling Work Effort

As important as developing proper motivation, and, indeed, contributing to the group's motivation, are the methods of controlling the work efforts of members of the unit. The procedure suggested covers all facets of controlling work and it does it in an orderly manner.

For best results, a work assignment should be in written form. This way the manager has the opportunity to think through his instructions, make sure that they are complete and that the language is not ambiguous or hazy. The man being assigned the work also has something to which he can refer to make certain he's on the right track.

Assignments should be dated at the time they are discussed with the man involved. They should also bear an estimated completion date.

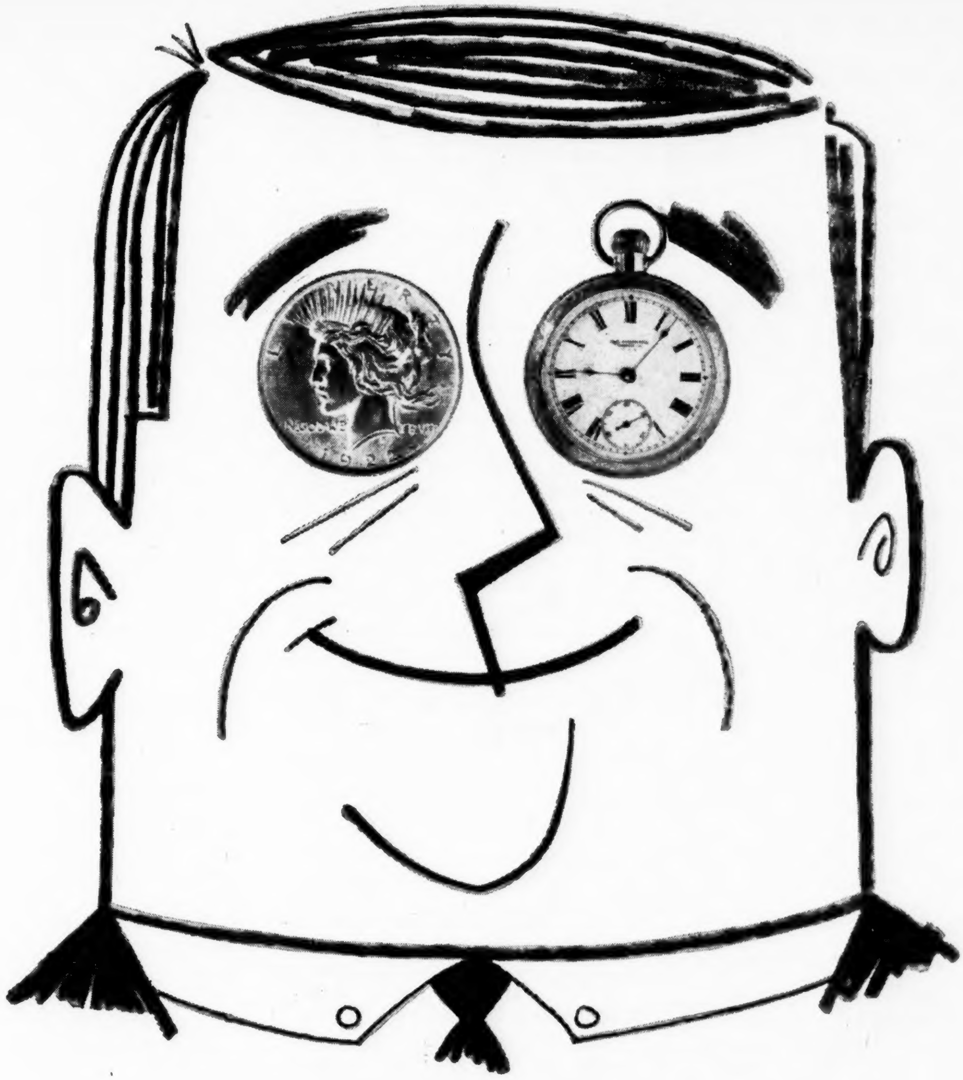
Discussions of assignments can be brief, but they should give the man an opportunity to ask questions and give the manager an opportunity to check the man's understanding of his assignment and check on his ability to meet the estimated completion date.

Keeping Track

Although other means may be used, a "Commitment Book" has been found extremely helpful in keeping track of work assign-

Next Month: How to Get Your Article Published

The next time you apply for a job or are up for promotion someone is going to take a long hard look at your record of technical publications. Why haven't you published more and what can you do to improve your own record? How can your technical articles improve your professional recognition? Next month You & Your Job will tell you how to write your technical articles to gain acceptance from technical editors. H. C. McDaniel of Westinghouse has gone right to the horses' mouths to gather these writing tips. His article is an authoritative survey of the likes and dislikes of 25 top business magazine editors.



TIME IS MONEY... SAVE BOTH!

ORDER NITROGEN PRODUCTS FROM SINCLAIR NOW

There are two big reasons why you should sign now with Sinclair for your supplies of nitrogen solutions, anhydrous ammonia and aqua ammonia.

First – the completion and opening of a centrally-situated new plant in Hammond, Indiana, means substantial savings in delivery time and shipping costs for most Mid-West nitrogen users.

Second – your seasonal supply problem can be solved by this plant's vast storage capacity... products will be delivered when you need them to meet your production schedule.

Let Sinclair help you solve your nitrogen supply problems and save you time and money in the bargain. Phone or write...

SINCLAIR CHEMICALS, INC.

(Affiliate of Sinclair Refining Company)
600 Fifth Avenue, New York 20, N. Y. – Phone Circle 6-3600
155 North Wacker Drive, Chicago 6, Illinois – Phone Financial 6-5900

ments. When an assignment is made and discussed with the man involved, it is entered into the book along with its date of entry and a note on its relative importance and priority.

This helps the manager follow up on the jobs assigned according to their importance and priority and can be used to close out a job with a note on the quality of performance when the work is reported completed. It also helps the manager assess the performance of his group against budgeted performance.

Review, Evaluate, Counsel

Periodic personnel evaluation can be another important method of motivating and controlling the work of engineers. With the engineer, as with most other people, knowledge that the work being done is important and will not be overlooked is usually an important consideration.

In many companies this is recognized by an official policy. The superior is directed to evaluate his men at stated intervals, report his rating to higher management and discuss both the rating and the reasons behind it with each man individually. Some firms even carry this procedure one step further and have the superior prepare his report to management in the presence of the man being evaluated.

By sticking to this open and established policy, each man's doubts and vague wonderings about his rate of progress can be put to rest.

In addition, these regular and formal conferences between the man and his superior can be the keystone of the superior's work in motivating and controlling the man's efforts. It is probably the manager's best opportunity for building the man's pride in his company, in his group and in himself. It's also an occasion for supervisory recognition of accomplishments and for directing the man's efforts in strengthening his weaknesses and improving his performance.

TAXES
. . . Sock Moving Costs

One of the lures used to entice engineers to a new job, free transportation and moving, is losing a little of its lustre as it rubs against the tax laws.

As a rule, costs of moving to a job in a new town are considered a personal expense, thus not deductible for income tax purposes. When the new employer picks up the tab, the law says the reimbursement is actually added compensation, to be tacked on to the employee's gross income.

Cost of moving an employee already on the payroll is much lower, since it is considered a business expense, not income to the employee. Thus it can be cheaper for a firm to hire a man at a branch near his home, then transfer him to another company location.

This practice, however, is now coming under Congressional fire. Rep. Mollohan (D., W. Va.) contends that present regulations discriminate against small business in favor of large, multiplant operators. He further cites the complaints of atomic energy workers whose moves were paid for to meet competition for their talents and who now are being billed for back taxes. Since these shifts were made for the nation's benefits, he argues, the moving expenses should not be considered compensation.

FIRING
. . . What Are Causes

Absenteeism and poor performance on the job were the most frequently mentioned reasons for discharging employees in a recent survey of personnel officers from 129 companies.

Conducted by the American Management Assn., the survey asked each personnel director to specify the reason or reasons for firing his company's most recently discharged employee.

Of the 129 firings, absenteeism was responsible for 35 and poor job performance was blamed in 28 cases. However, 33 respondents cited more than one reason for discharging the same person. And since 28 of the multiple responses included some mention of poor performance, it may be considered to account, at least in part, for 56 discharges.

Results of the survey indicate that male workers are fired for absenteeism more frequently than female workers. About 37% of the discharges to males were for this reason, only about 9% of the females discharges involved lost time. Since many prior studies have indicated that absenteeism is more prevalent among women employees, it can be concluded that employers consider losing time from the job a more serious offense in a man and are inclined to overlook this with a woman.

DOUBLE SALARIES
. . . For Engineers

Speaking to the Committee on Research of the National Assn. of Manufacturers recently, Dean John R. Dunning of Columbia University's School of Engineering noted:

"Everywhere you turn, it is the shortage of manpower that limits our industrial growth and our defense program. However, so far, all solutions proposed to finance the real costs of education have been only palliative measures and almost negligible dollar-wise.

A few cents of each dollar of our national income would remedy the situation in meeting the needs of our colleges. To double our whole educational expenditures would be a small fraction of our total national income.

From another viewpoint, if industry wants to solve the engineering and scientific manpower shortage problem, the straightforward solution is simply to double the salaries of engineers and make a reasonable ratio between engineers and skilled labor.

Word will then get back to the high schools, 'If you go into science and engineering, it is almost worthwhile; you will get paid more than a fireman or bricklayer.'"

PEOPLE . . .

TECHNICAL BOOKSHELF

J. B. BACON

Hydrocarbon Catalysis

CATALYSIS. Vol. 4. Edited by Paul H. Emmet. Reinhold Publishing Corp., New York. 576 pages. $12.50.

Reviewed by F. C. Nachod

While the main subject of this book is heterogeneous catalysis, the eight chapters are a very homogeneous accounting of problems of particular interest to the coal and petroleum industries. Over half the contents is devoted to the Fischer-Tropsch process; the rest, to shorter contributions dealing with isosynthesis, methanation, hydrogenation and aromatization.

What this reviewer said about the first three volumes holds equally well for the present one: The book is a credit to editor and contributors and is a must on the shelves of the chemist or chemical engineer working in the above-mentioned industries.

Word in Organic Synthesis

SYNTHETIC METHODS OF ORGANIC CHEMISTRY. Vol. 10 By W. Theilheimer. Interscience Publishers, New York (S. Karger, Basel). 746 pages. $25.25.

Reviewed by E. A. Steck

It was almost ten years ago when the series on "Synthetic Methods" was begun, in German, in a modest way as an annual survey of preparative art in organic chemistry (*Chem. Eng.*, Sept. 1948, p. 316). The continuing, patient efforts of the author have made Theilheimer *the* word for a compendium of modern organic synthesis.

Well-integrated pattern of organization, together with closely knit cumulative indexes for each five volumes, make the wealth of information as accessible as one would hope. In development work, the series will offer backgrounds of alternative routes which may suggest improvements in old procedures.

There is every reason to endorse Theilheimer with enthusiasm, from the tempo-reflecting section on the latest trends in synthesis, through all the clearly outlined procedures, to the multifaceted indexes. The entire set is uniform in character, well printed, remarkably free of errors and sturdily bound to withstand the use it deserves.

The price tag on this volume is less concern when one considers the well integrated whole and the value of the systematization produced by lavishing care throughout. It does, however, lead to the disquieting thought that soon the price may be at the Beilstein level, out of reach of the bench workers who should have Theilheimer near.

Unit Operations Milestone

UNIT OPERATIONS OF CHEMICAL ENGINEERING. By Warren L. McCabe and Julian C. Smith. McGraw-Hill Book Co., New York. 945 pages. $10.50.

Reviewed by M. C. Molstad

This book marks a significant milestone along Unit Operations Road, which began almost forty years ago with the mimeographed notes that became the first edition of Walker, Lewis and McAdams.

While written as a beginning textbook for junior and senior undergraduate students, this book is in no sense an elementary treatment. Coverage of each important unit operation is carried through to its current status as regards both theory and practice. It provides a well-organized, comprehensive, rigorous basis for a three-semester sequence of courses.

The chapter on flow of heat covers all important applications of theory, methods of calculation and equipment, making it the longest chapter in the book.

Material on basic operations of fluid flow has been greatly expanded, as compared with other texts, and forms a 100-page chapter titled "Fluid Mechanics." The following chap-

ter, "Transportation of Fluids," can thus give major emphasis to description of equipment and practical information as to its operation.

Similarly, the "Mass Transfer" chapter includes theory underlying a number of unit operations and is followed by chapters devoted to equipment and particular applications of theory to gas absorption, distillation, extraction, crystallization, air-water operations and drying.

Particularly valuable features of the book are 113 worked-out examples, nearly 150 unsolved problems, 500 figures and 275 references to chemical engineering literature. And many of these references are to publications of the last three or four years.

Quoting from the preface:

"Many of the less conventional operations, such as absorption, dialysis, expression, colloid milling, ion exchange, freezing, sublimation and specialized methods of mechanical separation, are omitted because of space. Other important topics have been left out both because of space and because any adequate treatment of them would raise the level of the book to a point inaccessible to the undergraduate. For these reasons, multicomponent separations, transient phenomena and operations at extremes of temperature, pressure or velocity have been omitted or touched on but lightly."

The book can be strongly recommended, not only as a text, but as very useful in providing the practicing engineer with a clear, complete and up-to-date review of the various unit operations.

I. G. Farben Heritage

DAS ERBE DER I. G. FARBEN (The Heritage of I. G. Farben). By W. O. Reichelt, written in cooperation with Dr. Manfred Zapp. Econ Verlag GmbH, Duesseldorf. 248 pages. DM 14.80.

Reviewed by Karl Falk

Germans and Americans will probably never agree and will long be sensitive about the rea-

sons for breaking up the I. G. dye trust after World War II. This book does little to clear up the misunderstandings.

The German view, as expressed by Reichelt, still seems to be that "anti-I. G. fanatics," trying out "experimental anti-trust theories," wanted to eliminate Germany from world markets and therefore broke up the former world's largest chemical combination.

The author considers it paradoxical that Carl Duisberg, and Friedrich Bayer got the idea from the United States that eventually led to the former I.G. and that it was also from the U. S. that the idea came for its destruction. What he seems to miss when referring to large American firms is the fact that Du Pont, for example, is not the largest producer of any major chemical group and that there has always been more intra-industry competition in the U. S. than was evident in prewar Germany.

In America the good features of cartels are often ignored. In Europe, on the other hand, the dangers of restrictive practices of cartels are soft-pedaled. Nevertheless, as a sequel to Fritz ter Meer's earlier book, *Die I. G. Farben* (Econ Verlag, 1953), which covered mainly prewar and war developments, the new book takes the I. G. successors and the German chemical industry generally past the point when they were returned to German control in 1955.

It is interesting to see how the Germans themselves view the painful struggle to rebuild their chemical industry after destruction, dismantling and decartelization. Nobody likes to lose a war. Occupation is not a happy affair for occupier or occupied. Americans realize that many mistakes were made in the immediate postwar period and in the unhappy Nuernberg war-crime trials. The latter included 23 former I. G. officials, most of whom were acquitted or given relatively light sentences. The German view, of course, is that they should not have been tried at all. But there is little regret expressed and little admission of any responsibility of the chemical industries for suffer-

ings or practices in occupied territories during the war.

On the positive side, the book gives a good picture of the progress that has been made to overcome obvious obstacles in ten years of allied control. German industry has adjusted to new conditions and has climbed to fourth place as a world chemical producer.

Definite assurances are given that there is no intention in Germany to resurrect I. G. in its old form. There is some evidence of collaboration in trying to avoid duplicating research and market facilities and in atomic developments, but the I. G. successors are in a healthy condition and apparently intend to continue competing as independent units.

As a key industry in the economic development of a resurgent Germany, the chemical industry shows reassuring evidence of a sincere interest in world-wide, and especially in European, cooperation.

Whether one agrees or disagrees with the tone and conclusions of Reichelt's book, it is a worth-while summary of postwar legislation affecting I. G. It contains much up-to-date information on organizational and financial details and production programs. It ends on an optimistic note for the future, despite such problems as increasing world price competition, domestic tax burdens and concern over the fact that half the former I. G. plants still lie behind the "iron curtain."

Thoroughly Revised Text

EXPERIMENTAL PHYSICAL CHEMISTRY. 5th ed. By Farrington Daniels, Joseph H. Mathews, John W. Williams, Paul Bender and Robert A. Alberty. McGraw-Hill Book Co., New York. 493 pages. $6.50.

Reviewed by F. C. Nachod

The original edition of this book appeared in 1929 and has been the basis of a rigorous experimental physical chemistry course at the University of Wisconsin.

In the present edition, the three senior authors have coopted two of their colleagues and

have thoroughly revised the list of experiments. They've added new tasks for their present crop of students in such fields as chromatography, thermal analysis and high vacuum techniques.

The book is recommended to universities and colleges who wish to produce as good a student as the Madison group has been able to do for about thirty years.

Statistical Mechanics

STATISTICAL MECHANICS, Priniciples and Selected Applications. By Terrell L. Hill. McGraw-Hill Book Co., New York. 425 pages. $9.

Reviewed by E. J. Lawson

Dr. Hill's text, intended primarily as an advanced treatise, recounts developments in the last decade or two in statistical mechanics—particularly as applied to some topics of current interest such as liquid state theory.

Emphasis is placed, therefore, on the use of such devices as cluster integrals, distribution functions and lattice statistics. Based on these concepts, the work is mainly concerned with the general theory of condensed states, including solids and imperfect gases as well as liquids. But there is also an excellent treatment of fluctuations which draws chiefly on more traditional ideas.

This work should find a receptive audience among advanced students and research workers who already have a good groundwork in statistical mechanics, and want to grasp some of the trends in the extensive recent literature.

Recommended

ORGANIC CHEMISTRY. 3rd ed. By Louis F. Fieser and Mary Fieser. D. C. Heath & Co., Boston. 1,117 pages. $9.

Reviewed by F. C. Nachod

This excellent organic text which first appeared in 1944, and then in its second edition in 1950, has now been revised by the Fieser team. The six years between the second and third edi-

tions have been rich with new developments. And it's therefore not surprising that an almost complete rewriting has been necessary.

Among the new materials treated, the reader will find molecular orbital theory and emphasis on reaction mechanism. Concepts of conformational analysis which has been extremely exciting to most physical organic chemists is developed in Chapter 12.

Short telescopic biographical sketches which had been employed by the German translator of this work impressed the authors so that they now list over 450 short entries and footnotes, thus bringing to life a name associated with a particular reaction or discovery.

The Fieserian feline, trademark of the Fiesers, this time occupies a prominent position atop a Buchner funnel. This book can be wholeheartedly recommended to chemists concerned with the organic field.

BRIEFLY NOTED

STANDARDS ON PETROLEUM PRODUCTS. 1,050 *pp.* $6.75. *American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.* Special compilation of ASTM standards covering petroleum products and lubricants. Lists methods of testing for properties and constituents of petroleum products; ways of specifying gasoline, fuel oils and petroleum spirits; definitions of terms relating to specific gravity and rheological properties; recommended practices in designating significant places in specified limiting values; classification of diesel fuel oils.

CHEMICAL ENGINEERING FACULTIES, 1956-57. 62 *pp. F. J. Van Antwerpen, Executive Secy., American Institute of Chemical Engineers, 25 W. 45th St., New York 36, N. Y.* Offers useful information to company personnel representatives, university faculty and administrative officers, prospective graduate and undergraduate students on chemical engineering faculties in the U. S. and Canada. Included under each school listing: name of school; address; whether or not accredited by AIChE; length of time required for completion of undergraduate curriculum; availa-

bility of evening courses; departmental faculty (listed according to rank); information on departmental, college or university placement service.

INDUSTRIAL RESEARCH AND DEVELOPMENT IN THE PHILIPPINES. *83 pp. By R. N. Shreve, R. H. Ewell, T. W. Alder. National Economic Council, International Cooperation Administration, 815 Connecticut Ave. N. W., Washington, D. C.* Includes discussions of present status of and future needs in industrial research and development for the Philippines; general principles of industrial research and development for the islands; selection, control and evaluation of industrial research and development projects; recommendations for a National Institute of Industrial Research and Technology.

MORE NEW BOOKS

DOCUMENTATION IN ACTION. By J. H. Shera, Allen Kent and J. W. Perry. Reinhold. $10.

ELECTROCHEMISTRY, PRINCIPLES & APPLICATIONS. By E. C. Potter. Macmillan. $10.

ELEMENTS OF ENGINEERING MATERIALS. By C. P. Bacha, J. L. Schwalje and A. J. Del Mastro. Harper. $6.50.

ELEMENTS OF ENGINEERING THERMODYNAMICS. By R. H. Sabersky. McGraw-Hill. $7.50.

ENCYCLOPEDIA OF CHEMICAL REACTIONS. Vol. 6—Sm, Sc, Se, Si, Ag, Na. By C. A. Jacobson and C. A. Hampel. Reinhold. $12.50.

ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY. Vol. 15. Edited by R. E. Kirk and D. F. Othmer. Interscience. $30.

ENGINEERING USES OF RUBBER. Edited by A. T. McPherson and A. Klemin. Reinhold. $12.50.

NUCLEAR ENGINEERING. By C. Bonilla. McGraw-Hill. $9.50.

ORGANIC ANALYSIS. Vol. 3. Edited by J. Mitchell, Jr., I. M. Kolthoff, E. S. Proskauer and A. Weissburger. Interscience. $11.50.

OUT OF THE TEST TUBE. 5th ed. By H. N. Holmes. Emerson Books. $4.50.

PATENT NOTES FOR ENGINEERS. 7th ed. By C. D. Tuska. McGraw-Hill. $4.

PHYSICAL METHODS IN CHEMICAL ANALYSIS. Vol. 3. Edited by W. G. Berl. Academic Press. $15.

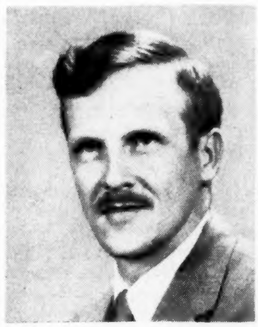
PUMP SELECTION AND APPLICATION. By T. G. Hicks. McGraw-Hill. $8.50.

RUBBER CHEMICALS. By J. Van Alphen. Elsevier. $5.

SEWAGE TREATMENT. By K. Imhoff and G. M. Fair. Wiley. $7.50.

PEOPLE . . .

MEET YOUR



Ralph Cushing

YOUR DESIGN REFERENCE FILE PAGE 257.

It's not everyday that this column has "cloak and dagger" material to expound on but here's one exception in the person of Ralph Cushing.

Cushing rates this description because of his service during World War II with the Office of Strategic Services (the US Government's espionage agency). As a follow-up, he completed military service after the war as a member of a parachute rescue team for the US Air Force in Labrador.

But Cushing's interests aren't limited to foreign intrigue and high adventure by any means. He's a licensed Methodist minister, Sunday school teacher and active youth worker too. What's more, his most absorbing hobbies include food catering and cake decorating along with photography and horticulture. And, he also owns up to being a devoted "do-it-yourself fan."

To top off this interesting array of varied interests and experiences, Cushing has already chalked up a good record in the field of chemical engineering—though he graduated only five years ago from Drexel Institute of Technology, in Philadelphia.

He started out in 1952 as a design engineer at Bristol Laboratories, Inc., in Syracuse, N. Y. In the Spring of 1956, he taught plant and equipment design to seniors at Syracuse University. Then last July, he joined Mobay Chemical in St. Louis, Mo., as a design engineer.

AUTHORS
M. A. GIBBONS

Cushing makes his home in St. Louis, Mo. He is an active member of the AIChE.

Norman Fishman

High Temperature Technology. Page 237.

While Norman Fishman's comment that he indulges in garden maintenance — usual pastime for dwellers of Suburbia, U. S. A., low level of exertion—may foster the belief that he tends toward indolence, actually he may have little energy left after burning it up in high-temperature research. Since November, 1954, he has been in the midst of Stanford Research Institute's programs on high temperature and solid rocket propellants.

Before joining Stanford Research, Fishman worked on recovery processes associated with fixation of nitrogen by the Wisconsin process, at Food Machinery & Chemical Corp., San Jose, Calif. You'll find evidence of first-hand knowledge of the problems involved when you read the section of "High Temperature Technology" that deals with this process.

Fishman also worked for a while at Western Regional Utilization Branch, U.S.D.A., Albany, Calif.

At the University of California, Berkeley, Fishman received his B. S. in 1948 and took some part-time graduate work during the school year 1951-52.

During World War II, Fishman served in the Pacific on a ship carrying Navy refrigerated

cargo. At present, he is a USN Lieutenant attached to a Naval Reserve Research Company, which meets at Stanford.

Fishman is active in the ACS, AIChE, and the ARS.

W. E. Parkins

SELECT BEST HIGH TEMPERATURE COOLANT. PAGE 253.

The job of trying to describe William Parkins in terms of his main field of study would not only be difficult but inaccurate, as well: His scientific background is a bit too varied.

First, Parkins earned a B. S. degree in electrical engineering from Montana State College in 1937. For the next two years, he studied civil engineering at Cornell as a McMullen research scholar. Then, he stayed on at Cornell to round off his education with a Ph. D. in physics.

In 1942, he joined the university of California Radiation Laboratory as a research associate. During the next four years, Parkins worked in Berkeley, Calif., and at Oak Ridge, Tenn., on the electromagnetic method for the separation of uranium isotopes.

Then, in 1946, he began a two-year stint at the University of Southern California as an assistant professor of physics. And, for the past nine years, Parkins has been associated with North American Aviation, Inc. Just now, he's chief of engineering for the Atomic International Division, where he engineers nuclear reactors for peacetime applications.

Parkins is a member of the nuclear engineering division of the American Institute of Chemical Engineers, the American

Association for the Advancement of Science, and a fellow of the American Physical Society.

Nevin K. Hiester

HIGH TEMPERATURE TECHNOLOGY. PAGE 237.

When Nevin Hiester stopped by our New York editorial offices to check galley proofs early in January, we welcomed a veteran contributor to our columns. Because Hiester lives in California, we were lucky to be able to renew acquaintance with him. Most of his contact with *Chemical Engineering* has been through Elliott Schrier, CE's able western editor who is based in San Francisco.

That this contact has been continuing and fruitful is evidenced by the mounting weight of first-rate *CE* articles authored and co-authored by Hiester. Working closely with Schrier, Hiester and collaborators have authored a feature report on ion exchange, October, 1954; a three-part article "Tools for Tomorrow — High Temperatures," December, 1956; and the present report on "High Temperature Technology"—a grand total of 42 pages.

By this time, readers of CE are well aware of Hiester's position among West-Coast chemical engineers where he is manager of chemical and metallurgical engineering, Stanford Research Institute, Menlo Park, Calif. We hopefully predict that many of his colleagues in the Pacific-coast area will follow his lead and become regular contributors of heads-up engineering articles in the columns of *Chemical Engineering*. Hiester is an active member of the AIChE.

AUTHORS . . .

F. Alan Ferguson

HIGH TEMPERATURE TECHNOLOGY. PAGE 237.

If you should drop by the Stanford Research Institute during lunch hour, most likely you'll find soft-spoken Alan Ferguson, sandwich in hand, vying for supremacy at the bridge table. For along with fellow author Norman Fishman and other co-workers, he prefers to feed his brain with this competitive intellectual exercise rather than shut it down while nourishing the body.

Ferguson might be characterized as a man who approaches life with single-minded purpose. Right now, he devotes his spare time almost exclusively to finishing the interior of his new home. Earlier, during the period 1950-51, he took time between jobs to travel extensively in Europe.

Following completion of his chemical engineering education with an M. S. at University of Washington in 1949, Ferguson joined Mountain Copper Co., Martinez, Calif. In 1951, he went with Kaiser Aluminum & Chemical Corp., Permanente, Calif., to work on wet and dry processes for producing artificial cryolite.

Just a little over a year ago, Ferguson took on his present assignment at Stanford Research Institute, in Palo Alto, Calif.

Here, while working on Institute-sponsored programs in the fields of high temperature and nuclear engineering, he gained much of the experience responsible for his part in the current report.

Ferguson—like report co-authors Hiester and Fishman—is an active member of the American Institute of Chemical Engineers in the San Francisco Bay area.

PEOPLE . . .

LETTERS:

Pro: Independent Status

Sir:

In your December report on the nuclear industry, you imply on p. 209 that Esso Research & Engineering was affiliated with Battelle in the establishment of our nuclear research center.

Esso is one of the major sponsors of nuclear research here; they signed a three-year contract with us last April for comprehensive studies to develop applications of atomic energy for the oil industry.

However, our nuclear research center—completion of which was announced when our 1-mw. reactor went critical in October—was established independently by Battelle.

R. O. STITH
Battelle Memorial Institute
Columbus, Ohio

Ch. E.'s vs. Terrazzo Setters

Sir:

This letter refers to Prof. Stewart's recent article, "Does Chemical Engineering Pay?" (Sept. 1956, pp. 192-194).

First be it noted that patternmakers earn \$3.25-3.75/hr., terrazzo and tile men recently received a fantastic \$4.25/hr. contract from an acquaintance of mine, ordinary steel labor is slated for \$2.80/hr., etc., and overtime means double time in most cases.

I have the equivalent of five years' experience, a strong business background, hold a B.S. Ch.E. and expect to receive an M.S. this year. If I fail to sell my services to a company this summer at a wage level reasonably above that of skilled and semiskilled labor, there will be one less engineer available to industry. Prestige, recognition, social status and "potentiality" don't pay the mortgage, food bills and other factors of comfortable living.

It is unfortunate that we don't have a monopolistic union, such as the American Medical Association, which insures a high economic status for its

PRO & CON

C. H. CHILTON

members. Most engineers and scientists are too weak-kneed to do anything about their poor salary position. They thrive in an intellectual, salary-less vacuum.

This "engineer shortage" that everyone writes about is strictly a shortage of engineers who are willing to work for laboring wages. It's no wonder that high school graduates avoid difficult engineering curricula when other, far less strenuous endeavors are more highly paid.

Messrs. Meany, Reuther and MacDonald must be having a rib-shattering laugh at our expense. We need more men of the caliber of Dr. Stewart to bring this salary problem to the foreground for concerted action.

ALEX JUNG

Princeton, N. J.

▶*If you've missed earlier comments about Prof. Stewart's provocative article, see Nov. 1956, pp. 402-405; Dec. 1956, pp. 396-400; Jan. 1957, p. 307.—ED.*

Pro: Liquid Ion Exchange

Sir:

In your *Chementator* item about the use of "liquid ion exchangers" to recover uranium (Dec. 1956, pp. 103-104) you leave the impression that development of solvent extraction originated at AEC's Oak Ridge laboratories. Other groups also played a major role.

The ability of alkyl acid phosphates to extract uranium from aqueous solution was first reported in early 1950 by University of California Radiation Laboratory and by Hanford Engineering Works. Both groups had observed the presence of more powerful extractants in systems containing tributyl phosphate.

We at Dow were unaware of their work when in early 1951, as a contractor to AEC's raw materials division, we found that mono- and dialkyl orthophosphates, as well as the pyrophosphates, were effective extractants for uranium in strong

H_3PO_4 solutions. Development of the H_3PO_4 solvent extraction process was carried up to the pilot-plant stage, where it was taken over to International Minerals, U. S. Phosphoric and Virginia-Carolina (*Chem. Eng.*, May 1956, pp. 130-132).

In May 1951 we also experimented with sulfuric acid solutions and obtained extremely encouraging results which indicated that vanadium, as well as uranium, could probably be recovered. Process development was accordingly begun.

In August 1951 the Oak Ridge raw materials group entered the field and undertook to screen a large number of compounds for their ability to extract uranium. This group had already done a considerable amount of work with the more fundamental aspects of raw materials problems and had contributed greatly to the understanding of the chemistry of these systems.

While our development work indicated long-chain monoalkyl orthophosphoric acids (C_{12} and greater) to be the most attractive compounds, the Oak Ridge group eventually concentrated on dialkyl (mainly dioctyl) orthophosphates. The monoalkyl phosphate process has been piloted by Dow and the Bureau of Mines at Salt Lake City and also by the Vitro Co. The latter has a full-scale plant under construction.

The dialkyl phosphate (DAPEX) process has been investigated principally by the Oak Ridge group and by National Lead Co. at Winchester, Mass. The amine (AMEX) process originated at Oak Ridge and was also mainly developed there, but substantial contributions have been made by National Lead, Rohm & Haas and the Bureau of Mines. Both of these processes have been piloted, as you reported, and full-scale plants are under construction.

RICHARD H. BAILES
Dow Chemical Co.
Pittsburg, Calif.

▶ *We're glad to get this distinction, overlooked in our Chementator story, between the monoalkyl and dialkyl phosphate processes. See also another letter on this general subject below.*—ED.

Pro: Solvent Extraction

Sir:

The growing use of solvent extraction in uranium processing, as well as in other metal processing problems, was pointed out in your December *Chementator* (pp. 103-104) and was attributed largely to the greater adaptability of solvent extraction to continuous processing methods.

Two other important advantages of solvent extraction processes should be mentioned:

- Greater versatility in the selection of the active functional group.
- Potential application to pulps (40-60% solids) and to dry ores.

The one major difficulty with solvent extraction—the loss of solvent by entrainment—has, we feel, been largely overcome for slurries of up to 5% solids. This is largely the result of studies carried out under AEC contract by Dow and the Bureau of Mines at the bureau's pilot plant in Salt Lake City.

The bureau has taken over this work and is continuing the study of slurry and pulp contacting. Considerable work has been done on pulps of 40-60% solids, and the application of solvent extraction to this type of system is a definite possibility.

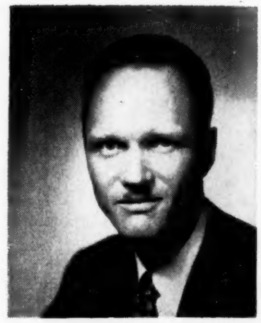
The versatility of solvent extraction lies in the fact that countless potential organic extractants are soluble in water-immiscible solvents, but the number of active groups available on ion exchange resins is limited at present to a few types. Although this advantage is of less importance in the case of uranium (where the commercial strong-base resins happen to be extremely selective for uranium), it is likely to be quite important in considering potential application in other metal processing problems.

In view of the world's increasing reliance on lower-grade sources, there should be a large field of application for solvent extraction in the recovery and separation of not only the rarer metals, but many of the commoner ones as well.

ROBERT R. GRINSTEAD
Dow Chemical Co.
Pittsburg, Calif.

PEOPLE . . .

NAMES IN



Berndt Lyckberg

New general manager of W. R. Grace & Co.'s new high density polyethylene plant at Baton Rouge, La., is Berndt K. Lyckberg.

Since 1951, Lyckberg has been manager of the chemical laboratories of Firestone Plastics Co., Pottstown, Pa. And, for most of the past 17 years, he has been closely associated with manufacturing of synthetic polymers.

During the war, he assisted in setting up Firestone Tire & Rubber's synthetic rubber plants at Akron, Ohio, Lake Charles and Port Neches, Tex. He also served as technical director at the latter plant.

Lyckberg received his chemical engineering degree from Armour Institute of Technology. Graduate work was done at the Institute and at the University of Kansas City.

Adolph Q. Lindquist has been appointed a vice president of Union Carbide Nuclear Co. Till now, he had been general manager of Colorado Plateau operations at Grand Junction, Colo.

Richard O. Westley is now general manager of The Glidden Co.'s Chemurgy Division. He'll direct all soybean processing and grain mechandising operations of the Glidden unit.

Myron W. Colony has been named advisory engineer at American Potash & Chemical's main Trona, Calif.,

THE NEWS

M. A. GIBBONS

plant. He'll coordinate basic planning on major projects.

George T. Bayley and **John B. Calkin** have announced the formation of a new firm of industrial consultants—Calkin & Bayley, Inc., New York —for the chemical process industries. Calkin had been with Foster D. Snell, Inc.; Bayley, with the Journal of Commerce.

William S. Landers, 43, was appointed chief of the U. S. Bureau of Mines' regional coal technology branch at Denver, Colo.

Roy C. Newton

The American Institute of Chemists has selected Roy C. Newton, vice president of Swift & Co., Chicago, to receive its 1957 gold medal, for his "leadership in food technology and his service to the profession."

Newton has held his present position at Swift & Co. since 1941. Over the years, he has helped to build the firm's research staff which has contributed many improved forms of food products. And, he saw to it that the firm's research fellowship program has been extended to many colleges and universities.

Before joining Swift in 1924, Newton taught chemistry at Oklahoma A. & M., Purdue and Lewis Institute. And, in that year, he earned his doctorate at the University of Chicago.

Probably best known of his

work in research is his discovery and application of gum guaiac as an anti-oxidant in lard. He holds many patents relating to the stabilization of oils and fats.

The AIC award will be given during the Institute's annual meeting, May 22-24, at the Sheraton-Mayflower Hotel, in Akron, Ohio.

Thomas D. Parks

Clorox Chemical Co., Oakland, Calif., has elected Thomas D. Parks as its new vice president-research.

Parks first joined the West Coast firm as director of research in September 1955. Before that time, he had been chairman of the department of chemistry and assistant director of the physical science division of Stanford Research Institute, in Palo Alto, Calif.

D. T. Rogers, senior research associate of Esso Research & Engineering Co., has been elected a vice president of the Association of Harvard Chemists for 1957.

Donald H. Wheeler has been appointed head of the chemical research department of the General Mills' research lab in Minneapolis, Minn.

Donald L. Dewing has been named director of quality control of General Tire & Rubber Co. He had been manager of quality assurance for the Aerojet-General subsidiary.

J. Dean Herman has been named a VP and director of chemical plant operations of Lithium Corp. of America. Till now, he had been in

charge of construction of the firm's Bessemer City, N. C., plant and manager of the St. Louis Park plant.

F. A. Sherwood, associate director of engineering at Monsanto Chemical's Texas City, Tex., plant, will head up plastics division efforts to select new sites for petrochemical and polymer operations.

Patrick M. Dowling is now manager of Stanford Research Institute's Washington, D. C., office. Formerly, he headed the Pacific Northwest office in Portland.

J. F. Roorda, Jr., has been appointed assistant superintendent—technical at Shell Chemical's Houston, Tex., plant. Roorda is now operating department manager at the Norco, La., plant.

Morton J. Fainman, formerly senior project chemist for Standard Oil Co., (Ind.), has been named executive engineer for the cobalt 60 project of the Cook Technological Center, Morton Grove, Ill.

C. C. Currie

Dow Corning has set up a new products department to handle its expanding silicone business with C. C. Currie as group leader.

Currie became associated with Dow Corning when Dow Chemical's basic silicone research groups were organized as the Dow Corning Corp., in 1943. Four years before, just after graduation from Alma College in Michigan, Currie had joined Dow Chemical as a chemist in the

ethocel division. Then when Dow Corning was formed, he held the post of manager of the fluids section, process engineering laboratories.

The new products group will be attached to the present product engineering organization.

T. A. Phillips, vice president of Arizona Public Service, is chairman of a new Arizona statewide engineering organization known as the Arizona Council of Engineering and Scientific Associations.

James N. Hinyard has been appointed director of market development for American Potash & Chemical Corp., Los Angeles. Formerly, Hinyard was with Merck & Co., Inc.

William J. Urbowicz has been named product manager-alicyclic chemicals by National Aniline Division.

F. E. James has been promoted to group leader in the economics section of the research and development department of the American Oil Co.

Robert H. Brown is now assistant director of Alcoa Research Laboratories and **Charles J. Walton** is chief of Alcoa's chemical metallurgy division.

Sidney W. McCann

Former manager of the Rochester manufacturing division, Sidney W. McCann has been named technical advisor to the vice president in charge of manufacturing for The Pfaudler Co.

In his new post, McCann will

concentrate on technical problems of a ceramic nature in particular. He'll also serve as a consultant on these problems with foreign operations research engineering and sales.

Born in Hartford City, Ind., McCann has also been research director for the firm and spent some time overseas with Pfaudler's plants in Germany and Scotland.

Maurice Bigelow

Former director of research, Maurice Bigelow, has been appointed technical director of Allied Chemical & Dye's Barrett Division.

In his new post, Bigelow will head up the division's research and development department in New York City.

Bigelow graduated from Northeastern University and the University of Pittsburgh. He has been with the firm for the past 25 years. His record lists more than 50 technical articles, books and patents—primarily on plastics.

Morris B. Minkin and **Richard S. Ploss** have joined the staff of International Salt's main research laboratory in New York City.

Richard R. Bukacek has joined the chemical engineering staff of Illinois Institute of Technology, Chicago. Bukacek had been supervisor of natural gas transmission at the Institute of Gas Technology.

J. S. Atwood is now manager of the chemical department of Kopper's engineering and construction division. Until last October, Atwood had been a

manager of engineering development for U. S. Industrial Chemicals.

Robert J. Schatz, former associate director of research for Monsanto Chemical's plastics division, in Springfield, Mass., is now associate director of the Texas City, Tex., plant.

W. E. MacFarland, medical teacher and editor, has been appointed editor of professional literature for Parke, Davis & Co., in Detroit.

Joseph J. Joyce has been named to the chemical engineering staff of Pittsburgh Coke & Chemical's process improvement section, chemical plant engineering department.

Fred B. Ortman has been appointed associate director of Stanford Research Institute. Ortman retired, recently, as chairman of the board of Gladding, McBean & Co.

Norman E. Hathaway has been appointed to the new position of general sales manager for Oronite Chemical Co., in San Francisco.

B. D. Thomas

Battelle Memorial Institute, Columbus, Ohio, has announced the appointment of a new director—B. D. Thomas.

A member of the Institute's executive and technical staff since 1934, Thomas served most recently as a vice president. His activities include the setting up of Battelle's first division of Chemical research in 1939, development of the Institute's recently completed nuclear re-

search center, and publication of various papers on the methods of separating, sorting and concentrating of minerals.

Thomas is a graduate of the University of Washington where he was awarded a Du Pont fellowship in chemistry.

Charles L. Thomas

The annual honor scroll award of the American Institute of Chemists, Pennsylvania chapter, has been given to Charles L. Thomas—director of research and development for Sun Oil Co.

Thomas received the 1956 award "for his proficiency in his profession, his contributions to the science of petroleum chemistry and his work toward the advancement of the chemist."

Four months ago, Thomas was promoted from associate director of research at Sun Oil to his present post. He originally joined the firm in 1951 as a part of the research and development staff.

Max C. Farmer has been selected to fill the newly created position of technical director for Beryllium Corp., Reading, Pa. Formerly, he was staff metallurgist on the materials advisory board of the Nat'l Academy of Sciences in Washington, D. C.

Robert B. Crothers has been named to the newly-created post of air sanitation director for Contra Costa County, Calif. Most recently, he was an industrial hygienist with the Oakland, Calif., health dept.

John C. Lyman, formerly a member of the operating committee of Foremost Food &

Chemical Co., has joined the California Ink Co., San Francisco, as assistant to the president.

James H. Perry has been appointed a senior chemical engineer in the chemical engineering department of Atlas Powder Co. Perry had been a development supervisor for the Carwin Co., North Haven, Conn.

Arthur Blount, a Rohm & Haas vice president, has been appointed manager of the Philadelphia plant. **Paul D. Grubb** is assistant manager and production manager.

Ralph Bloom, Jr., formerly with Becco Chemical's special products department, has been appointed technical coordinator.

Carl S. Smith is now manager of Hercules Powder's Harbor Beach plant, (Huron Milling division). **F. J. Bouchard** will be his assistant.

Clement W. Theobald has been appointed assistant director of the research division of Du Pont's fabrics and finishes dept., in Wilmington, Del.

Arthur B. Tillman

The post of electro chemical division operations manager, for Diamond Alkali Co., Cleveland, has been filled by Arthur B. Tillman.

Since August 1955, Tillman has held the position of assistant works manager-operations of the Painesville (Ohio) plant.

A native of St. Louis, Mo., Tillman earned his B. S. and

M. S. degrees in chemical engineering at local Washington University.

W. Earl Dunn

Blaw-Knox Co., Pittsburgh, Pa., has appointed W. Earl Dunn as vice president-general manager of its chemical plants division.

Till now, Dunn had been a vice president and manager of J. F. Pritchard & Co.'s petroleum division, in Kansas City, Mo. His career also includes 20 years with Fluor Corp., Ltd., of Los Angeles, Calif.

—EAVESDROPPING—

"... Education in a democracy must not only be democratic, it must be education."

"To put it bluntly, our schools do not perform their primary purpose which is to train the nation's brain power to the highest potential . . . We shall not do justice to our talented youth until we seek them out at an early age—no later than ten or eleven—and educate them separately from the rest of the children. . . .

"For the past fifty years we have, in the name of educational democracy, tried to make one common school serve all children instead of finding the appropriate school for the two main groups of children—the majority who plan on non-academic careers, and the minority who plan for college and university. We must reverse the unfortunate trend in American education.

"I suggest that industry, to-

NAMES . . .

gether with our educational foundations undertake the setting up of model academic secondary schools in perhaps 25 different centers in the United States. These schools would be on a par with our best academic secondary schools. They would be free; the ability to pass an entrance examination of a kind which would seek out those not mentally capable of absorbing an academic secondary education would be the only requirement. The schools would be staffed by teachers truly capable of teaching talented children; teachers whose qualifications place less emphasis on training in teaching methods and more on graduate study in their fields.

"Teachers' salaries in these schools would be in accord with the high scholastic qualifications required and, therefore, equal to those paid for comparable positions in industry.

"These model schools should aim at a ratio of at least one teacher for every 20 pupils and would start with the fifth grade so as to have the pupils ready for college at 16. We must find a way for our children to attend school for more than the present 180 days. Lengthening the time in school might most easily be done through the medium of voluntary summer courses.

"I estimate that the cost of operating each model school for five years will be about ten million dollars. At the end of the period the community ought to have an option to take over the school, provided it agrees to continue the high scholastic standards set under private management.

"We must not forget that well-to-do parents always have it in their power to assure their children a good education by sending them to private preparatory schools. But the talented poor child must depend solely on the public school. Education in a democracy must not only be democratic, it must also be education.

"No matter what methods are chosen in the duel between the communist and the free world, education will, in the final analysis, determine the outcome, particularly the education of talented youth . . ."

---

* Admiral Rickover, USN, chief of the naval reactors branch of the AEC, spoke at the seventh Thomas Alva Edison Foundation Institute, on science education, Nov. 20, 1956, in East Orange, N. J.

Kenneth T. Bell has been named academic director of the nuclear reactor technology program which has been set up by Case Institute of Technology.

G. John Lambillotte has been appointed project engineer for Columbia-Southern Chemical Corp. His work will involve process engineering and economic studies for the research and development department.

Kenneth C. Loughlin has been elected executive vice president of Celanese Corp. of America. **John W. Brooks** will succeed Loughlin as general manager of the firm's textile div.

James Jensen has been named manager, plant engineering for American Potash & Chemical Corp. in Trona, Calif. **Howard Barker** will be his assistant.

Robert S. Rogers has been appointed head of the Seattle chemical department of Van Waters & Rogers, Inc.; David L. Porter will be his assistant.

C. G. Youngquist, manager of Koppers' Petrolia, Pa., plant, has been promoted to chief engineer of the chemical division's development department.

Leland D. Pratt, vice president of Kelco Co., chemical manufacturing concern, has been elected president of the San Diego Employers Assn.

C. A. Cocks, Convent Station, N. J., has been appointed New York, district sales manager of Johns-Mansville's celite division.

Rollin E. Stevens—a specialist in geo-chemistry—has been named to the staff of the Union of Burma Applied Research Institute under a contract with Armour Research Fundation, Chicago.

Paul W. Wentworth has been elected executive vice president of Vulcan-Cincinnati,

Inc. **Robert F. Romell** is now vice president of the company as well as general manager of Vulcan Mfg. Div.

Nelson D. Griswold has been named a director of Dow Chemical Co. and Texas division assistant general manager in charge of engineering and utilities as chairman of a divisional executive board.

William B. Thomas has been named to the post of plant manager of Kaiser Aluminum & Chemical's newly acquired plant at Dolton, Ill.

Chester L. Knowles, Jr., former supervising engineer for Monsanto Chemical's engineering department, plastics division, has joined his father's engineering firm—Knowles Associates.

Stirling Tuner has been promoted to the newly created post of assistant to the plant manager of Chemstrand's nylon plant in Pensacola, Fla. He had been with General Motors Corp.

Ralbern H. Murray has been appointed assistant secretary of the American Gas Assn.'s industrial and commercial gas section.

J. W. McLaughlin has been named manager, film and sheeting division, Bakelite Co.

Robert B. Lautner is now manager of the Moundsville, W. Va., chlorine-caustic soda plant of Solvay Process Division.

Janos Kollonitsch, hydride chemist who escaped recently across the Hungarian border into Austria, has joined Metal Hydrides, Inc.

Robert Q. Sharpe, staff engineer of Socony Mobil Oil's industrial division, lubricating department, is now chief engineer.

Earl D. Stewart has been appointed associated associate technical director of Schwarz Laboratories, Inc. **Joseph L.**

Owades has been named to succeed Stewart as chief chemist.

Kenneth W. Newman has been appointed to the position of chief process engineer for Turco Products, Inc., Los Angeles.

D. H. Roderick has been promoted from power engineer to assistant chief engineer of the design engineering group at Jefferson Chemical Co.'s Port Neches, Tex., plant.

Guy Z. Moore will take charge of the styrene plant to be built by El Paso Natural Gas Products Co., near Odessa, Tex.

J. W. Fordham, senior chemist for Diamond Alkali's exploratory research department, at Painesville, Ohio, is now group leader for monomers and polymers research.

OBITUARIES

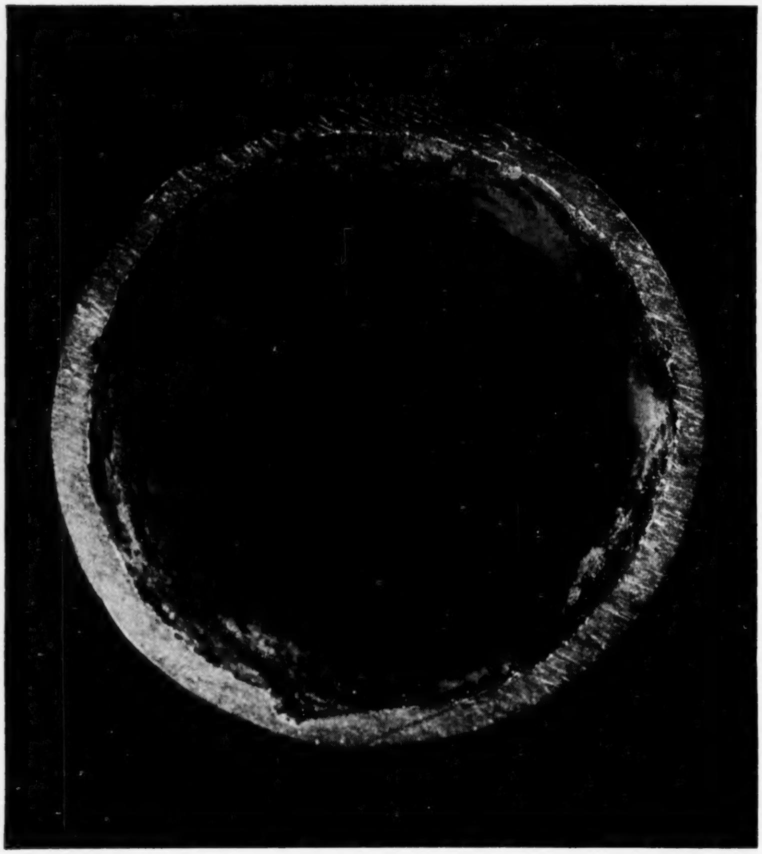
V. F. Parry, former chief of the U. S. Bureau of Mines' regional coal technology branch at Denver, Colo., died December 16.

Arthur Parrett, 60, a vice president and director of research for Rayonier, died of a heart attack, December 27 at Seattle, Wash. Before he joined the firm in 1932 as chemical director in Shelton, Wash., he had been associated with Du Pont and the A. O. Smith Corp.

Eric G. Davis, former vice president and general manager of Titanine, Inc., lacquer manufacturing concern, died December 17 of a heart attack. He was 66 years old.

W. E. Dugan, Jr., manager of Solvay Process Division's Moundsville, W. Va., chlorine-caustic soda plant, died suddenly December 28.

Ferdinand W. Breth, vice president and technical director of L. Sonneborn Sons, Inc., New York chemical firm, died January 8 of a heart attack.



Using vertical polarized light on a cross-section of pipe, photographer Bernard Hoffman clearly shows the ravages of corrosive action.

PEOPLE . . .

FIRMS IN

New Companies

Sel-Rex Corp., Newark, N. J., has been formed by merger of Sel-Rex Precious Metals, Inc., and Bart-Messing Corp. New firm consists of three divisions: chemical, precious metals and rectifier.

Cahn Instrument Co., Downey, Calif., has been formed to design, manufacture and sell scientific instruments.

Hawthorn Chemical Corp., formed jointly by Hercules Powder Co. and Imperial Chemical Industries, will build and operate an $11-million methyl methacrylate plant at Louisiana, Mo. Administrative offices are in Wilmington, Del.

Popular Plastic Products Corp., Northport, N. Y., has formed a subsidiary, Popular Fiberglass Products Corp., to manufacture reinforced-plastic products.

McGuire and Co., Oakland, Calif., has incorporated as McGuire Chemical Co. Firm specializes in industrial chemicals, packaging and distribution.

Oxysynthese, Paris, France, has been formed by L'Air Liquide and Ugine, two French chemical companies. New firm will make oxygenated water.

Heyden Newport Chemical Corp. resulted from a merger of Heyden Chemical Corp. and Newport Industries Inc.

Francaise des Petroles has formed French Petroleum Co. of Canada, with headquarters in Calgary, Alberta, to handle most of its Canadian operations.

Solar Salt Co. has been formed by merger of Chemical Salt Production Co. and Stansbury Salt Co. Chemical Salt was a joint affiliate of

THE NEWS

J. B. BACON

Hooker Electrochemical Co. and Pennsylvania Salt Mfg. Co.

Valley Products Co., Philadelphia, has announced formation of a separate manufacturing division: Lawrence Plastic Container Co.

Amoco Chemical Corp. has been formed by three Standard Oil (Ind.) subsidiaries.

New Facilities

Texas Gulf Sulphur Co. has begun construction of a multimillion-dollar sulfur mining plant at the Fannett Dome about 15 mi. southwest of Beaumont, Tex.

Canadian Marietta Co. has completed its $500,000, 2-million-lb./mo. plant in Edmonton, B. C., for producing synthetic resins and adhesives.

Celanese Corp. of America is building a new acrylic ester plant in Pampa, Tex., with a capacity of 15 million lb./yr. Plant will be on stream in late 1957.

Pacific Yeast Products has built a $250,000 research laboratory in Wasco, Calif.

Shell Oil Co. will install a 2,400-bbl./day alkylation unit at its Anacortes, Wash., refinery. Unit, to be built by Fluor Corp., will be on stream by mid-1958.

Carborundum Co. will build a new multimillion-dollar plant at Van Wert, Ohio, to make small vitrified abrasive wheels.

Indonesian Government Cement Plant, Gresik, Java, will have a capacity of 250,000 metric tons/yr. when it begins full operation some time in 1957. Crushing equipment, grinding mills and two 11-ft. by 375-ft. kilns with all auxiliary equipment for the mill are being

FIRMS . . .

furnished by Kennedy-Van Saun, Danville, Pa.

Dow Chemical Co. has purchased a 50% interest in Productos Quimicas Mexicano, S. A., producer of caustic soda and chlorinated compounds. Productos Quimicos is the largest electrolytic caustic plant in the Federal District of Mexico.

Diamond Alkali Co. has a new bulk terminal system at McKees Rocks, Pa., specially designed to handle perchlorethylene. Terminal will service a 15-state area extending from New England to W. Va. and from Eastern Seaboard to Ohio and western Mich.

Fluor Products Co. has formed a separate division to design, prefabricate and market a complete line of cooling towers for the air-conditioning and refrigeration industry.

Michigan Chemical Corp. is about to launch a \$2.5-million expansion plan. Present ideas call for developing its rare earths and thorium division.

Monsanto Chemical Co.'s inorganic chemicals division has formed a technical service group as part of its sales organization for agricultural chemicals.

Procter & Gamble has acquired substantially all the assets of Charmin Paper Mills in exchange for common shares of Procter & Gamble stock.

Sinclair Research Laboratories has completed a nuclear radiation laboratory in Harvey, Ill. Facilities will house a gamma-ray source containing the "hottest" spent-fuel elements thus far made available to industry by the Atomic Energy Commission.

Canadian Industries, Ltd., is planning a new \$3-million sulfuric acid plant at Copper Cliff, Ont. The 300-ton/day plant will make acid for uranium processing and will be on stream next December.

Celotex Corp., manufacturer of building products, has acquired 12 acres of land and 60,000 sq. ft. of building space at Des Plaines, Ill., for construction of a research center.

U. S. Oil & Refining Co. will install a 2,500-3,000 bbl./day Houdriformer at its Tacoma, Wash., refinery.

Valve Products, Inc., subsidiary of Rockwell Mfg. Co., is building a valve parts plant at Knox, Ind., to produce parts for high-pressure, high-temperature valves and lubricated plug valves.

Beckman Instruments has acquired Watts Mfg. Co., Ronceverte, W. Va., makers of continuous-action gas chromatographs and process control instruments.

Vereinigte Aluminum - Werke AG, of Berlin and Bonn, West Germany, will boost aluminum production to 115,000 tons/yr. to meet steadily increasing demand.

Surface Combustion Corp.'s Webster Engineering Co. Div. plans a new plant in Tulsa, Okla., to manufacture gas burner equipment.

Douglas Oil Co. of California has awarded a contract to Macco Corp. for construction of a $400,000 Unifining unit at Douglas' Bakersfield, Calif., refinery. Unit is scheduled for completion by June 1957.

California Standard Co. will build a gas scrubbing plant, costing in the neighborhood of $10 million, in southern Alberta's Pricess field area to prepare gas for entry into the West-East Trans-Canada pipeline system. Construction will start when pipeline is completed.

Hooker Electrochemical Co.'s Oldbury Div. is boosting sodium chlorate capacity at its Columbus, Miss., plant by 5,000 tons/yr. to an annual capacity of 22,000 tons. Addi-

FIRMS . . .

tional electrolytic cells and finishing and bulk storage facilities will cost close to $1-million.

Standard Oil Co. (N. J.) announced plans for construction of a $30-million, 40,000-bbl./day refinery near Oslo, Norway. Plans, subject to approval by the Norwegian Parliament, call for the refinery to be on stream in 1960.

Cornwall Chemicals has upped carbon bisulfide production by 60% at its Cornwall, Ont., plant.

Shell Oil Co., will build a 12,-000-bbl./day platinum catalyst reformer at its Wilmington - Dominguez, Calif., refinery. Construction contract has been let to Kaiser Engineers Div. of Henry J. Kaiser Co., Cleveland.

Badger Mfg. Co., has begun work on a naphthalene purification plant for Barrett Div. of Allied Chemical & Dye Corp. Facility, expected on stream late this year, will be located at Barrett's Philadelphia, Pa., site.

Morningstar, Nicol, Inc., has tripled capacity at its Hawthorne, N. J., site for grinding, blending, treating and compounding of water-soluble gums.

Wyandotte Chemicals Corp. will build a $20-million electrolytic chlorine-caustic plant at Baton Rouge, La., which will boost the firm's chlor-caustic capacity by nearly 60%. Plant is due on stream in late 1958.

Fischer & Porter Co. has opened a new sales office in Indianapolis, Ind.

Olin-Mathieson Chemical Corp. has completed facilities at McIntosh, Ala., on the Tombigbee River for water shipments of chlorine and caustic soda.

Narmco Resins & Coatings Co., Costa Mesa, Calif., will boost output of aircraft structural

adhesives and laminating materials through a $225,000 expansion program scheduled for completion this month.

Wolverine Tube Div. of Calumet & Hecla has opened new office and mill-depot facilities in Atlanta, Ga., to stock copper water tube, refrigeration tube and automotive tube.

Standard Oil Co. (Ind.) now has a $2-million electronic data-processing machine—an IBM 705—at its Whiting, Ind., refinery. Machine is now doing accounting jobs, will soon figure refinery yields and maintain inventory controls.

Griscom-Russell Co. is constructing facilities at Massillon, Ohio, to develop and fabricate heat exchangers for the Atomic Energy Commission.

Socony Mobil Oil Co. de Venezuela has awarded a contract to Williams Brothers, Tulsa, Okla., to build a 212-mi., 20-in. crude pipeline in Venezuela. Pipeline will cost about $25 million.

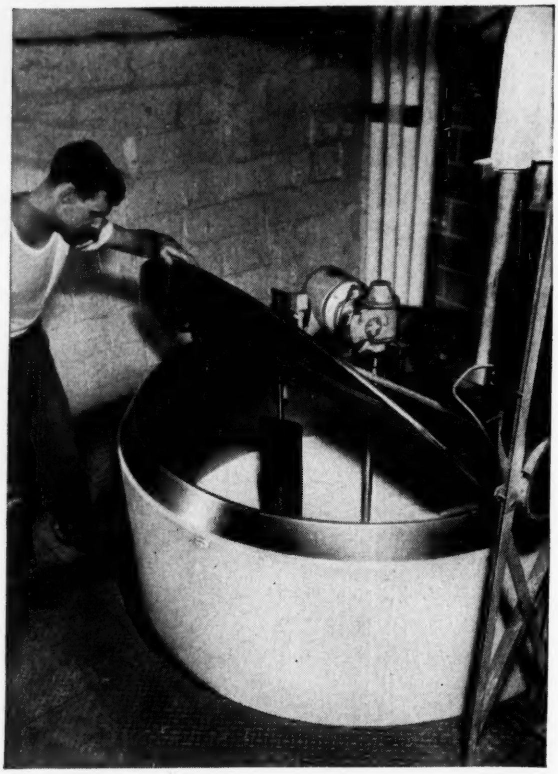
El Paso Natural Gas Products Co., El Paso, Tex., has acquired McNutt Oil & Refining Co.

Koppers Co. will build 174 Koppers-Becker combination coke ovens for Inland Steel Co. at Inland's Indiana Harbor works in East Chicago, Ind. Ovens will be in operation in late 1958.

Standard Oil Co. of California will build a 60,-100,000 bbl./day, $65-million refinery near Everett, Wash.

General Mills, Minneapolis, Minn., has purchased Protex, S. A., of Mexico City, Mex., producers of steroid compounds.

Central Minera, S. A., Mexican subsidiary of Texas International Sulphur Co., has contracted with Fish Service de Mexico, S. A., to build a $3.5-



million Frasch-type sulfur plant on the Isthmus of Tehuantepec in Mexico. Fish will train management personnel.

Sterling Drug, Inc., has acquired The d-Con Co., Chicago, maker of rodenticides. Pending startup of Sterling's new Alliance, Ohio, plant about mid-1957, production will continue at the present d-Con plant in Chicago.

Guardian Paper Co., of Emeryville, Calif., will build a $200,000 plant at Newark, Calif., for manufacture of plastic-coated linings used in multiwell bags. Plant will be on stream in summer 1958.

Balfour-Guthrie & Co. has plans for a $250,000 synthetic resin plant at Tacoma, Wash., to supply Pacific Northwest plywood industry.

Mobay Chemical Co. is just now completing its first additional unit for production of isocyanate chemicals at its New Martinsville, W. Va., plant. Move is a step in Mobay's drive to up production by about 200% to get maximum efficiency in urethane chemicals manufacturing.

Imperial Oxygen Ltd. is building a new $100,000 plant in the Burnaby district of Vancouver, B. C. for manufacture of oxygen and acetylene.

Catalin Corp. of America is constructing a new laboratory for the development of special chemicals at the Fords, N. J., plant at a cost of approximately $500,000.

Kieley & Mueller, Inc., Middletown, N. Y. is forming a new nuclear power equipment division.

Association of American Railroads is building a $500,000 engineering laboratory at its research center in Chicago.

Portco Corp., Vancouver, Wash., manufacturer of paper and plastic bags, liners and sheeting for agricultural and in-

dustrial use, has purchased the plastic pipe manufacturing facilities and assets of the former M & M Wood Working Co., Portland, Ore., from Simpson Logging Co.

Modern Packaging Co., Ltd., Alberta, Canada's only producer of polyethylene packaging bags, has started full-scale production at its new $100,000 plant in the Manchester district of Calgary.

Colorado Planning Commission has approved the expenditure of $250,000 by the University of Colorado to be matched with $1.5 million in funds from private sources for establishing an atomic research center, including a cyclotron —an atom smasher.

Hercules Powder Co. has acquired Huron Milling Co., Harbor Beach, Mich.

Chemway Corp. has acquired Carac Corp., Freeport, N. Y., manufacturer of insecticides, fungicides and fertilizers for garden use.

Canadian Industries Ltd. has purchased Witts Fertilizer Works Ltd., Norwich, Ont., manufacturer of compound fertilizers.

Columbia-Southern Chemical Corp., Barberton, Ohio, has set in operation new manufacturing facilities for the production of high grade calcium chloride.

Victor Chemical Works is acquiring a large industrial site in Chicago to construct an important addition to its midwestern manufacturing facilities.

Du Pont Co. (United Kingdom) Ltd. has taken options on a 381-acre tract near Londonderry, North Ireland, as the prospective site for a neoprene synthetic rubber plant.

Wyandotte Chemicals Corp. has purchased a 242-acre site at LaSalle Canyon near Lompoc, Calif., to build a plant for the production of an oil and

FIRMS . . .

water absorbing product for use on floors in industrial plants.

Dow Chemical Co. is producing higher-purity magnesium pig and ingot, destined for use in production of priority defense metals. The purer grades are now available in volume.

Imperial Chemical Industries Ltd.'s second oil-cracking plant at Wilton, England, has started production.

Pathfinder Chemical Corp., the Niagara Falls plant of Goodyear Tire & Rubber Co., is planning a $4-million expansion program to provide for the increased production of Pliovic vinyl resins.

Daiichi Bussan Co. and Toyo Soda Industry Co. have announced plans to start production of tetraethyl lead in Japan.

Ellis E. Patterson & Associates have obtained an option on several thousand acres of land in northwest Saskatchewan as a berth for a new $30-million pulp mill.

Columbia-Southern Chemical Corp. is beginning exploratory operations in Liberia, West Africa, in a search for titanium bearing ores.

Timber Engineering Co. has opened expanded plant and facilities of its research and development laboratory.

Douglas Oil Co. of California is constructing a unifining process unit at its Bakersfield Refinery which will substantially increase the company's capacity for producing high octane motor fuels.

Miller Chemical & Fertilizer Corp., Baltimore, Md., has acquired the Lancaster Bone Fertilizer Co. plant at Ephrata, Pa.

Du Pont Co.'s new Fort Hill works, near Columbia Park, Ohio, is now producing sulfuric acid.

Archer - Daniels - Midland Co., Minneapolis, has purchased an interest in Scado Kunstharsindustrie, NV, a leading Holland manufacturer of resins and plasticizers, with plant and offices at Zwolle.

Beckman Instruments, Inc., has acquired Watts Manufacturing Co., Ronceverte, W. Va., manufacturer of a new, continuous-action gas chromatograph.

American Meter Co. has opened two new plants in Fullerton, Calif. and Garland, Tex.

Interchemical Corp. has opened a new pilot laboratory at Hawthorne, N. J.

Air Reduction Sales Co. has acquired Jackson Products, Inc. of Detroit, manufacturer of welding supplies for the electric arc welding field.

Granite City Steel Co., Granite City, Ill., is planning a \$150-million expansion program to increase ingot production 50% to a total of about 2.4 million tons/yr.

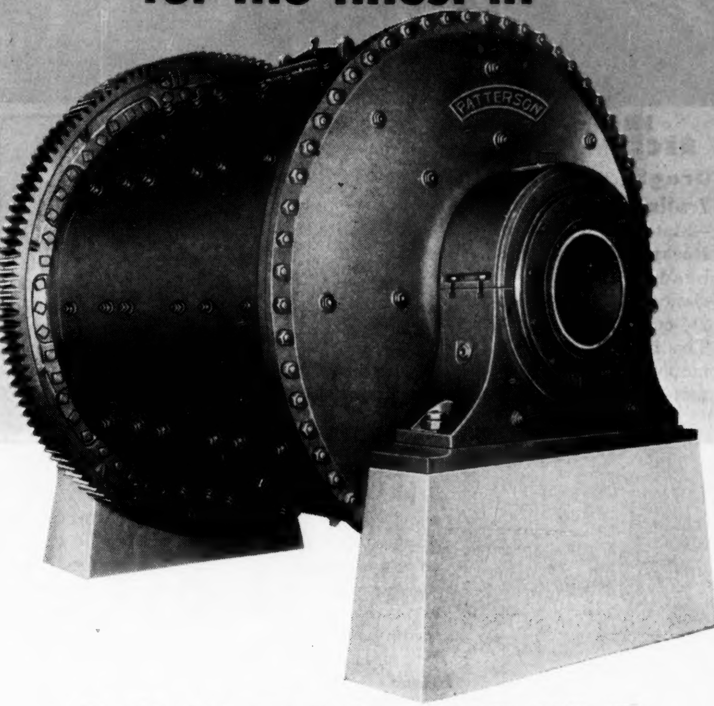
Delta Refining Co., Memphis, Tenn., is building a packaged Girbotol plant to purify 1,500 bbl./day of a propanebutane liquid hydrocarbon mixture by removing 10,000 lb. of hydrogen sulfide.

Bunker Hill Co., San Francisco, has acquired Associated Lead & Zinc Co., Seattle, Wash.

Celotex Corp. has acquired 12 acres of land and 60,000 sq. ft. of buildings in Des Plaines, Ill., as a major step in expansion of its research activities.

Warren Steam Pump Co., Warren, Mass., is planning to open a second plant at Peace Dale, R. I.

Pittsburgh Plate Glass Co.'s Columbia Cement Div., Zanesville, Ohio, has placed in operation a new rotary kiln which is electronically controlled and highly instrumented. The new cement producing facilities are de-



FIRMS . . .

scribed as being perhaps the closest to a completely automatic production plant in the cement industry.

Du Pont Co.'s new multimillion dollar plant in Antioch, Calif., has delivered the first bulk shipment of West Coast-produced Freon propellent to a Los Angeles firm.

Kaiser Aluminum & Chemical Corp. plans to build an aluminum reduction plant by 1961 in Douglas County, Wash., provided a Columbia River hydroelectric project survives a legal tangle and is completed.

O'Brien Corp. is increasing its nationwide paint production capacity 25% through a $500,000 expansion of its South Bend, Ind. headquarters plant.

J. O. Ross Engineering Corp. has acquired Andrews & Goodrich, Inc. of Boston, Mass., manufacturer of ventilating equipment and dryers for all types of textile materials and products.

Stauffer Chemical Co. has established another unit in its 17-plant network of agricultural chemical plants at Phoenix, Ariz.

Tri-Point Mfg. & Developing Co., precision industrial plastics firm, has moved into new facilities in Albertson, L. I. The new plant more then triples the productive capacity of the company.

Case Institute of Technology, Cleveland, Ohio, has a new chemistry and chemical engineering building.

Bailey Meter Co. has acquired the trade name, know-how, and other assets of Metrotype Corp., Michigan City, Ind.

Rust Engineering Co. has completed a new engineering office in Birmingham, Ala.

Kaiser Aluminum & Chemical Corp. has installed a new assemblyline method of pour-

ing 50-lb. aluminum pigs at the Mead reduction plant at a cost of more than $134,000.

New Lines

Velsicol Chemical Corp., producers of chlorinated insecticides, has entered the phosphate insecticide field with the manufacture of technical methyl parathion.

Carbide & Carbon Chemicals Co. will license Carbide patents which cover three new instruments for measuring automatically streams of gases and liquids in production processes.

Philadelphia Insulated Wire Co. has completed expansion for the production of Teflon-insulated wire.

Wagner Brothers, Detroit, Mich., makers of plating equipment and supplies, has entered the plating chemicals field.

New Representatives

Rodney Hunt Machine Co., Orange, Mass., has appointed Process Sales Co., Beaumont, Tex., as its representative for Turba-Film and other Rodney Hunt process equipment.

New Locations

Texas Butadiene & Chemical Corp. is moving its executive and sales offices from the Gulf Bldg., Houston, Tex., to the Bank of the Southwest Bldg., Houston.

E. F. Houghton & Co., manufacturers of industrial oils, chemicals and packings, has transferred sales and service offices to 222 Adams St., Chicago.

New Names

Pilot California Co., Los Angeles, is the new name of Pilot Chemical Co.

National Research Corp.'s equipment division has changed its name to NRC Equipment Corp.

Chemical Engineering

Reader Service

MARCH 1957

For More Information

Current technical literature is yours for the asking. And more information on chemicals and equipment, too, is easy to get. All you have to do is use one of the prepaid postcards inside the back cover. Take advantage of Chemical Engineering's unique Reader Service.

GUIDE TO TECHNICAL LITERATURE

PRODUCTS INDEX

INDEX OF ADVERTISERS

CHECK LIST OF REPRINTS

READER SERVICE POSTCARDS

READER SERVICE . . .
TECHNICAL

• Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

• It's easy — simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the literature.

Chemicals

Acid, Muriatic......Features high purity muriatic acid-Hooker White. This special grade is entirely free of arsenic. Contains .003% or less sulfates, & .0001% or less iron. Technical Data Sheet.
220c *Hooker Electrochem. Co.

Acids, Fatty......These fatty acids are readily available from the El Dorado Div.—caprylic, eldhyco, capric, lauric, coconut, palmitic and myristic. Company makes complete details available and offers samples.
L465a *Foremost Food and Chem. Co.

Adhesive.......For a neoprene-to-metal bonding adhesive: function, physical properties, composition, application by brush, spray or dip, agitation, advantages in terms of corrosion resistance, strength, handling operations.
430A Harwick Standard Chem. Co.

Alcohol, Furfuryl......Derived from agricultural residues & useful in manufacture of wide variety of products including resinous mortars, cements, binder resins, etc. Data on properties & uses in Bulletin 205.
40-1 *Quaker Oats Co.

Ammonium Salts......16 p. booklet covers chemical and physical characteristics of a line of quaternary ammonium salts ranging from germicidals to textile softeners and from emulsifiers to corrosion inhibitors.
430B Armour & Co.

Aromatics, Chlorinated......Hooker aromatic compounds give you easy, practical ways of putting benzyl, benzoyl, and nitrobenzoyl groups into organic compounds, particularly through Friedel-Crafts reactions. Data Sheets.
220b *Hooker Electrochem. Co.

Borohydrides......Two data sheets: one on sodium borohydride, No. 502-F; one on potassium borohydride, No. 301-B. They cover reactions, molecular weight, formula, melting point, thermal stability, storing, handling.
430C Metal Hydrides.

* From advertisement this issue

LITERATURE

C. J. ROHRBACH

Catalyst Carriers......Alundum carriers prove highly successful in reactions such as those involved in manufacture of phthalic anhydride, maleic anhydride and oxidation of ethylene. Full details in Bulletin No. 7.
69a *Norton Co.

Catalyst Supports......Made of dense, rugged, chemically inert material—have great resistance to breakdown—no chemically reactive effect on processing. Used in suspending beds for active catalysts. Request data.
69b *Norton Co.

Catalysts......"Harshaw Catalysts . . . Made to Your Specifications" includes sections on: typical Harshaw catalysts and how they are used; catalytic chemicals supplied by Harshaw, etc. Available upon request.
66 *Harshaw Chem. Co.

Ceramics......Covering a full line of industrial ceramics, 20 p. catalog includes selection chart with mechanical, physical and electrical properties for each. Tips on designing with ceramics and how-to-buy information.
431A Star Porcelain Co.

Chemicals.......More than 335 organic chemicals in a 24-p. booklet. Applications are presented and physical properties are given in tabular form. Called "Physical Properties of Carbide & Carbon Chemicals."
431B Carbide & Carbon Chem.

Chemicals......"How Hercules Helps" is the title of a new 36 p. picture booklet showing end uses of Hercules products and containing a brief history of the company. Booklet made available upon request.
375 *Hercules Powder Co.

Chemicals......Lists over 4,000 chemicals manufactured and distributed by this company. Included material on fine organics, inorganic reagents, indicators. Also provides information on certified biological stains.
431C Matheson, Coleman and Bell.

* From advertisement this issue

Contents of this issue . . .

LITERATURE . . .

Chlorine Dioxide......Booklet discusses bleaching of inedible fats with chlorine dioxides, methods of purifying tallow and other inedible fats and protect them against deterioration, how to determine bleaching effectiveness.
432A Olin Mathieson Chem. Corp.

Clays......2-p. data sheet on clays for rubber and latex applications. For a line of water-fractionated clays, gives typical analyses, uses, comparative data. Some products covered: Silica as SiO_2, aluminum as Al_2O_3.
432B Harwick Standard Chem. Co.

Coumarin......Specification on coumarin and tables listing its solubility in alcohol-water, glycerin-water and propylene-glycol-water mixtures are contained in a new folder. Compound is used mostly for aroma fixing.
432C Monsanto Chemical Co.

Cyclohexanone......Company now gives the resin, plastics, coatings and chemical industries a dependable new source of supply of Nadone Cyclohexanone. Minimum purity 99.0%. Bull. 1-19 gives properties, uses.
199 *National Aniline Div.

Defoamers, Silicone.......Dow Corning "Antifoam B" disperses immediately in aqueous solutions. No stirring or agitation required. Ready to use & ideal for continuous processing. Request particulars and free sample.
L467 *Dow Corning Corp.

Elastomers......Neoprene and Hypalon elastomers are used in improving products and cutting maintenance and replacement costs. Full details made available in free publication. "The Du Pont Elastomers."
209 *E I du Pont de Nemours.

Esters, Methyl......These methyl esters are readily available from the El Dorado Div.—caprylate, Eldo 18, caprate, laurate, coconate, myristate, caproate, palmitate. Company makes details available and offers samples.
L465b *Foremost Food & Chem. Co.

Fabrics......24 p. outlines the variety of industrial niches filled by fabrics today: coated fabrics and supported film, fabrics and rubber, fabrics in laminates, fabrics for abrasives. Foldout chart gives fiber properties.
432D Wellington Sears Co.

Fertilizers......"Use of Commercial Fertilizers — Particularly Nitrogen — in Forestry" by Hermann Mayer-Krapoll. 111-p. booklet discusses experiences in Germany with such practices as fertilizing plantings, pole trees.
432E Allied Chem. & Dye Corp.

Fibers, Textile......"Comparative Chemical Resistance of Fibers" reports on studies at school of textiles at North Carolina State College. Tables show effects of exposure of fibers to over ten corrosives. Bulletin X-48.
432F Du Pont Co.

Fillers......Data sheet covers types and grades of walnut shell flours available for use in fillers, extenders and air blast cleaning. Discusses such properties as proper screen sizes, moisture content, ash content.
432G Harwick Standard Chem. Co.

Fillers......Describes a line of flocking and filler types of material made from new reclaimed waste, cotton material, controlled in length and moisture content. Uses, advantages, packing of various grades is discussed.
432H Harwick Standard Chem. Co.

Fillers, Mineral......Micro-Cel absorbs up to 6 times its weight in water, remains a free-flowing powder even after absorbing twice its weight in liquids. Company offers complete data and samples of Micro-Cel.
211 *Johns-Manville Co.

Fluorine Compounds....Data sheets cover company's fluorine compounds produced in pilot plant quantities. These include mono-, di-, and hexafluorophosphoric acid, sodium monofluorophosphate, stannous fluoride.
432I Ozark-Mahoning Co.

* From advertisement, this issue

Furfural......28 p. booklet covers furfural, furfuryl alcohol, tetrahydrofurfuryl alcohol, Furafil lignocellulose, furoic acid, hydrofuramide. Includes information on application, properties, shipping and handling information.
433A Quaker Oats Co.

Hydraulic Fluids......16 p. booklet, F-40134, discusses the advantages and limitations of water-base, fire-resistant hydraulic fluids. Complete information use and maintenance. Describes laboratory test results.
433B Carbide & Carbon Chem.

Latex.......16 p. bulletin C-6-239T describes a fortified styrene-butadiene copolymer latex for paper coating. Data on mechanical stability, compatibility with starch and dextrin, stability to pigments.
433C Koppers Co.

Latex......20 p. booklet describes centrifuged natural hevea latex, product of British Malaya, and its processing in this company's plants. Photographs cover the whole route, from tree to final shipment.
433D Stein, Hall & Co.

Lithium Aluminum Hydride.....7 p. data sheet, 401-D. Covers chemical reactions, both organic and inorganic, bibliography, molecular weight, bulk density, color and form, stability, solubility data.
433E Metal Hydrides.

Lithium Compounds.......Data sheets cover properties and applications of a range of lithium compounds including, lithium bichromate, dihydrate; lithium bromide; lithium carbonate; lithium chromate dihydrate.
433F Foote Mineral Co.

Lithium Metal Dispersions.......Data Sheets describe methods for laboratory preparation of lithium metal dispersions in such dispersing mediums as mineral oil, petroleum and wax. Available on request.
78 *Lithium Corp. of America

Lubricant.......Discusses the properties of a fire-resistant fluid lubricant developed specifically as a lubricant for air compressors. Instructions for the conversion of compressors to the use of the new fluid.
433G Monsanto Chemical Co.

Molybdates.......15 p. bulletin covers properties, uses, classification, nomenclature and preparation of heteropolymolybdates. Contains a section on the use of literature on these compounds. Bulletin Cdb-12.
433H Climax Molybdenum Co.

Molybdenum......An up-to-date listing, with brief descriptions, of all this company's available bulletins on molybdenum and its compounds. Subjects covered include chemical data series, agriculture, analysis, ceramics.
433I Climax Molybdenum Co.

Plasticizer......4 p. data sheet, F-40079, on didecyl phthalate, plasticizer for the vinyl plastics industry. Covers its outstanding physical properties, tentative specifications, compatibility, physiological effects, performance.
433J Carbide & Carbon Chem.

Plasticizers......To promote quick and convenient comparison of qualities offered by the company's six plasticizers for PVC, 17 p. bulletin makes tabular summaries of most important properties. Service bulletin GP-8.
433K B. F. Goodrich Chem. Co.

*From advertisement, this issue

Any bulletin or catalog . . . yours for the asking
You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

LITERATURE . . .

Polyethylene......24 p. on this company's emulsifiable polyethylene. Data on many types of emulsions and emulsifiers, typical formulations for floor polishes, tables of emulsifiers.
434A Semet-Solvay Petrochem. Div.

Polyvinyl Chloride Compounds.....Offers 8 p. bulletin on rigid unplasticized polyvinyl chloride compounds. Geon 8700-A and 8750. Discusses the use of these compounds in manufacturing rigid vinyl pipe and fittings.
9 B. F. Goodrich Chem. Co.

Polyvinyl Materials......Summary of the properties and fields of application of the company's polyvinyl resins, plastics, latices and polyblends. Sections on calendering and coating, extrusions, insulation, foam and sponge.
434B B. F. Goodrich Chem. Co.

Potash, Caustic......Offers: solid, flake, granular, broken, crushed, powder, walnut, at 90% strength; solid and flake, at 85% strength; liquid, low-chloride at 45% strength. Full details available in bulletin.
220d *Hooker Electrochem. Co.

Potassium Carbonate.....Potassium carbonate is 3 times as soluble as sodium carbonate at room temperatures. Higher solubility permits the use and packaging of more concentrated solutions. Fact book and sample.
181 *Solvay Process Div.

Reodorants.......4 p. booklet describes the development of chemicals and methods of application to eliminate objectionable malodors from animal experimental laboratories. Two types of masking agents are described.
434C Rhodia, Inc.

Resins, Tetrafluoroethylene.......Teflon tetrafluoroethylene resins used extensively in process industries. Offer chemical inertness, high heat resistance, low-temperature toughness, etc. Properties & applications.
381 *E I du Pont de Nemours.

Sieves, Molecular......Linde molecular sieves can dry your gases—air, hydrogen, chemical streams—more thoroughly than any other commercial adsorbent. Will remove last traces of moisture. Full details in data sheets.
81 *Linde Air Products Co.

Silicates......Properties and applications of potassium silicates. Potassium oxide to silica molecular ratios, baumes and poises are given for the company's products. Called "Potassium Silicates, Properties, Uses."
434D Philadelphia Quartz Co.

Silicones......For a line of silicone emulsions, describes properties, dilution recommendations, uses, toxicity, compatibility. Discusses three individual emulsions; how to take best advantage of the properties of each.
434E Harwick Standard Chem. Co.

Soda, Caustic.....Company offers Caustic Soda Engineering and Handling Guide, Bulletin 102; Caustic Soda Buyer's Guide, Bulletin 101 and technical data sheet. Company makes all available upon request.
220a *Hooker Electrochem. Co.

Soda, Caustic......Four plants from the Great Lakes to the Gulf deliver Mathieson Caustic in the quantity and quality specified, shipped on precise schedules to meet your operating requirements. Technical literature.
147 *Olin Mathieson Chem. Corp.

Sodium Hydride......Data sheet 507C, 7 p., covers reactions, handling, safety equipment, first aid, storage, disposal of waste, bibliography, general properties. Charts and equipment drawings clarify various sections.
434F Metal Hydrides.

Sodium Hydride in Oil.......8 p. data sheet, No. 508-A. Covers typical characteristics of dispersions in Bayol 85 at 25 C., dispersing liquid, thermal stability, reactions such as typical condensations, handling.
434G Metal Hydrides.

* From advertisement, this issue

Sodium m-Silicate......Valuable data on Drymet anhydrous—the most highly concentrated form of sodium m-silicate. Drymet File Folder contains technical data and suggested formulations. Request your copy.
B477 *Cowles Chem. Co.

Solvents, Aromatic......Cover a very wide evaporation range. Their individual characteristics satisfy specific requirements in a great variety of formulations. See, "Shell Aromatic Solvents for the Coatings Industry."
155 *Shell Oil Co.

Specialties......8 p. booklet gives properties and application data on the company's wetting agents, latex compounds for upholstery and carpets, ultra-accelerators, rubber compounding materials.
435A Alco Oil & Chem. Corp.

Sugar.....52 p. brochure, "Quality Plus," analyzes present trend toward higher quality foods in the marketplace and evaluates the firm's liquid sugars in terms of how they may help processors upgrade quality.
435B Refined Syrups & Sugars.

Surfactants......Igepal CO surfactants were designed as an integrated and mutually compatible series of nonionics. Each Igepal CO has special performance properties. Request application information and literature.
115 *Gen. Aniline & Film Corp.

Vinyl Film......Summary of properties of cast film in 12 formulations is given to indicate its usefulness in a wide variety of applications. 20 p. illustrated booklet contains technical information on tensile strength.
435C Bakelite Co.

Water Repellents......6 p. folder tells how repellents based on silicones protect concrete highways, bridges and other concrete constructions from spalling and other troubles. Describes tests showing repellent effectiveness.
435D Union Carbide & Carbon Corp.

Construction Materials

Alloys, Casting......Comprehensive wall chart details information about 37 standard brass, bronze and nickel silver casting alloys. Includes various specifications and percentage compositions.
435E Henning Bros. & Smith.

Alloys, Haynes.......New booklet gives data on machinery parts made of Haynes alloys. Includes chemical composition, physical and mechanical properties, corrosion resistance and machining.
435F Haynes Stellite Co.

Aluminum......Facts and figures on applications of aluminum in the chemical industry appear in new 16 p. brochure, "Reynolds Aluminum Tanks and Vessels." Can resist strong corrosive action of ammonium nitrate.
135 *Reynolds Metal Co.

Binders, Latex.......Lytron 680 latex binder for both exterior and interior surfaces is described in 20-page bulletin. Material weathers extremely well, forms strong durable film quickly in variety of climates.
435G Monsanto Chemical Co.

Castings, Stainless Steel......Second edition of 28-page booklet gives detailed information on corrosion and heat resisting stainless steel castings. Physical properties and chemical compositions given.
435H Allegheny Ludlum Steel Corp.

Coatings......Charts give properties of coatings ingredients, including solvents, couplers, diluents, plasticizers. Properties covered include relative evaporation rate, median specific gravity, blush resistance.
435I Carbide & Carbon Chem.

* From advertisement, this issue

LITERATURE . . .

Coatings......There are three Norton Rokide coatings: Rokide "A" aluminum oxide, Rokide "ZS" zirconium silicate and Rokide "Z" stabilized zirconia. Proved in such critical applications as reaction motors.
215 *Norton Co.

Coatings......4 p. discusses company's PVC coatings for protection against corrosion. Pictures and describes six important steps in the procedure for coating parts and assemblies to insure maximum resistance.
436A Quelcor, Inc.

Coatings, Inorganic Zinc.......General, physical and chemical properties of Dimetcote described in 4-page bulletin. Used on cooling towers, tanks, piping, structural steel and stacks; is equivalent to galvanizing.
436B Amercoat Corp.

Coatings, Protective.......Series E-900 coatings are high solids modified epoxy formulations which result in toughness, resistance to abrasion and adhesion to practically any type of clean surface. Bulletin E-900.
445 *Ceilcote Co.

Coatings, Protective......For any equipment or surface that can be uniformly baked . . . Plastisol compounds offer easy, economical way to apply long-lasting vinyl coating protection. Data in Bulletin No. VP-1.
388a *Metal & Thermit Corp.

Coatings, Protective......32 p. selection guide to this company's line of coatings for stopping or preventing rust on nearly all types of rustable metal under exposure to a variety of conditions including salt spray.
436C Rust-Oleum Corp.

Fabrication & Erection......Plate fabrication and erection of vessels, tanks, towers, odd and intricately designed chemical equipment . . . to any size . . . of any material: steel, aluminum, stainless, etc. Cat. 54 B.
60 *Hammond Iron Works.

Fabrication, Plate......Heat exchangers—steel and alloy plate fabrication; containers and pressure vessels for gases, liquids and solids. Company makes full details available in bulletins on experience and facilities.
14 *Downingtown Iron Works.

Fabrics, Coated......Fabrics coated with silicone rubber and nylon resin described in 4-page bulletin. Fabrics used for diaphragms, gaskets, seals, tapes, conveyor belts, ducting and partitioning. Outstanding properties.
436D Connecticut Hard Rubber Co.

Finishes, Flow Coating......Brochure describes new flow-coating finishes used for large areas involving long flow paths. These finishes release bubbles instantaneously and hang well on edges and corners.
436E Interchemical Corp.

High Alloy Assemblies......Company offers a specialized high alloy fabricating service to meet your needs. Production of high alloy assemblies utilizing stainless steel. Inconel, Monel, Hastelloys, etc. Bulletin 561.
436F General Alloys Co.

Insulation, Glass Fiber......Brochure No. WPD-12 describes Microlite, Super Fine and Microtex flame-blown glass fiber insulating blankets. Charts illustrate thermal and acoustical values.
436G L.O.F. Glass Fibers Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking
You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

Insulation, Mineral Wool......New catalog lists full specifications for complete line of spun mineral wool industrial insulating products. Data covers more than 20 types of equipment and piping insulations.
437A Baldwin-Hill Co.

Insulation, Pipe......Snap-On is the only one-piece molded pipe insulation of fine glass fibers. Offers these advantages: highest thermal efficiency, lower applied cost, extremely light weight. Request product brochure.
331 *Gustin-Bacon Mfg. Co.

Insulations, Industrial......Kaylo-20 is a new, highly efficient pipe insulation for service at all temperatures to 1800°F. Made to fit pipes as large as 39" in diameter. Full details contained in free booklets.
195 *Armstrong Cork Co.

Liners, Tank......Bulletin 4EL describes new Boltaron corrosion-resistant tank liner with built-in thermal compensation. Made from unplasticized Type I PVC, liner will not buckle, crack, distort or sag.
437B H. N. Hartwell & Son.

Linings, Drum......Unichrome drum linings deliver resilient, seam-free, pore-free protection against such materials as acids, alkilies, salt solutions, alcohols, detergents, etc. Request descriptive Bulletin No. DL-2.
388b *Metal & Thermit Corp.

Paints, Aluminum......Silicone base protects hot surfaces up to 1,700 F. Unusual heat resistance permits use on previously unpaintable surfaces. Properties and uses described in Bulletin LL-4235.
437C Chem. Industrial Co.

Plastics.....Revised edition of Condensed Reference File of Bakelite Plastics provides ready reference of six major types of plastic currently used by industry in more than 50 different forms. Available to firms.
437D Bakelite Co.

Refractory, Insulating......Bulletin 856 discloses new method for suspending insulating refractory, walls and arches. Eliminates need or drilling holes in the refractory. Depends on use of stainless-steel clips.
437E Geo. P. Reintjes Co.

Steels, Clad......One side corrosion resistant nickel or high alloy; the other rugged, economical carbon or alloy steel. Permanent metallurgical bond produced by heat and pressure on rolling mills. "Clad Steel Equipment."
118 *Lukens Steel Co.

Steels, Rubber-Lined.......Ace rubber-lined steel . . . strength and pressures of steel plus chemical resistance of hard rubber. Excellent for alkalis, most inorganic acids, etc. Full details in Bulletin CE-52.
327c *American Hard Rubber Co.

Teflon......Bulletin covers line of Teflon products including thin-and-heavy-walled tubing and rod, steel pipe lining, insulated wire, sheet and machine parts. Also details Teflon's exceptional properties.
437F Haveg Industries.

Teflon Products......Teflon seal cages last many times longer than metal lantern rings under continuous corrosive attack. Teflon ring packings give months of leak-free service. Full details available in Bulletin CP552.
R468 *Chem. & Power Products.

Titanium......Shows resistance to chloride solutions and retains useful strength up to 800-1000F. Other advantages and data on application and fabrication of titanium alloys in descriptive Rem-Cru Review.
312 *Rem-Cru Titanium.

Zirconium.......Company's new, free zirconium publication, "More Zr Facts," is designed to provide the first continuing source of zirconium technical data to industry. Place your name on the mailing list.
13 *Carborundum Metals Co.

*From advertisement, this issue

Electrical & Mechanical

Bearings, Roller......Bulletin gives load ratings, dimensions and other data on Dodge-Timken Roller Bearings. Offer superior performance, dependability and long life. Delivered fully assembled, ready to mount. Bul. A638.
319c *Dodge Mfg. Corp.

Casters & Wheels......Featuring Darnelloprene treads (a soft resilient Neoprene rubber compound) . . . casters offer ease of movement, quietness, and protection for floors. Complete details available in Manual.
L468 *Darnell Corp.

Castings, High Alloy......High alloy castings to your order . . . large, small, special shapes, corrosion resistant, heat resistant and abrasion resistant. Melt and finishing are all controlled and tested. Bul. 3354-G.
352 *Duraloy Co.

Controls, Electrical......Covers the features of oil-tight heavy duty pushbuttons, selector switches, indicating lights, covers and enclosures. Also includes accessories and dimensional data. 28 pages.
438A Cutler-Hammer.

Controls, Tube Expander......Bulletin 56-1 describes new air-powered boiler tube expander drive and control. Discusses advantages of precise tube rolling and features of the new device. Request your copy.
438B Thomas C. Wilson, Inc.

Drives, Silent Chain......Book gives details and advantages . . . complete selection and technical data on Link-Belt silent chain drives. Humidity, heat, cold do not lower chain's better than 98% efficiency. Book 2425.
17 *Link-Belt Co.

Ejectors . . . . . . Trouble-free Penberthy ejectors (with no moving parts to get out of order) are available in bronze, iron, stainless steel, plastic and other materials . . . in standard and made-to-order designs. Catalog 512R.
128 *Penberthy Injector Co.

Electrodes, Welding......Complete line of resistance welding electrodes and accessories described in 28-page, 2-color catalog. Applications, specifications and dimensions of various components. Request your copy.
438C Ampco Metal.

Enclosures, Motor......New concept in protected enclosures for industrial a.c. motors described in Bulletin B-2501. Protection better than drip- or splash-proof designs yet max. temp. rise is only 40 C.
438D Reliance Electric & Eng. Co.

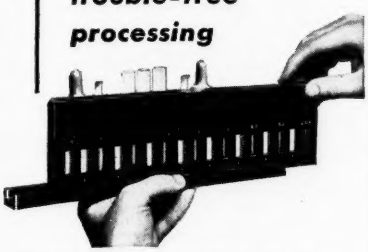
Fastenings . . . . . . 150,000,000 standard fastenings in brass, bronze, stainless, aluminum, copper, nickel and monel. Laboratory tests prove greater strength of Harper stainless steel machine bolts. Form 126.
336 *H. M. Harper Co.

Fuel Systems, LP-Gas......Fuel systems for industrial trucks approved by Underwriters' Laboratories, Inc. described in new specification sheets. Advantages explained, data, photos and performance figures.
438E Hyster Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking

You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.




MODERN
pH AND
CHLORINE
CONTROL


MOTOR PUMP

Lubricators, Conveyor......New 8-page catalog describes new automatic conveyor lubricators. Description deals with four fundamental improvements in one series and three in another. Includes exploded view.
440A J. N. Fauver Co.

Magnets, Perma-Plate......New Dings dynamic way to remove tramp iron from rapidly moving material. Perma-Plate Magnets for better magnetic separation in chutes, spouts, ducts. Request Catalog 1205-D.
443 *Dings Magnetic Separator Co.

Motor Starter-Circuit Breakers......Design, construction & performance of circuit breaker & motor starter Unilets give maximum safety & unparalleled ease of wiring, installation, maintenance. Bulletin BH.
101 *Appleton Elec. Co.

Motors......New Elliott C-W type N motors are designed for the utmost in dependability. They will withstand physical abuse. For complete information on performance and features, request new Motor Bulletin.
179 *Elliott Co.

Motors......Wagner Type EP Motors are fully protected against corrosive fumes and liquids, dust, dirt and moisture. Protection assured by totally enclosed, fan-cooled construction. Request Bulletin MU-203.
76 *Wagner Electric Co.

Packings, Asbestos Sheet......Durabla asbestos sheet packing is the one gasket material suitable for all temperature-pressure combinations. Used for sealing water, steam, all oils, gases, etc. Bulletin CE-37.
454 *Durabla Mfg. Co.

Pulleys, Motor......Reeves Vari-Speed motor pulleys get greater productivity; run at most economical production speed; handle production or process variables with the same machine. Request motor pulley bulletin.
325 *Reeves Pulley Co.

Reactors, Nuclear......Bulletin N-56-8 describes aqueous homogeneous power plant, includes cross-section and flow diagram. Bulletin N-56-9 describes research-type tank reactor. Designs based on 10-yr. experience.
440B Foster Wheeler Corp.

Reducers, Motors......Motors can be interchanged or replaced in minutes with the all-steel Falk motoreducer. Replacement is not limited to original make of motor. For more information request Bulletin No. 3100.
86 *Falk Corp.

Reducers, Speed......Feature all advantages of shaft-mounting . . . all proven performance & economy features of Dodge Torque-Arm speed reducers—available for your big jobs. Bulletin A-637 offers complete details.
319b *Dodge Mfg. Co.

Seals, Packaged ...... Request "John Crane" Type 9 Seal wherever "hard-to-handle" liquids or gases are involved . . . temperatures from –120° to 500°F . . . pressures to 750 psi. Complete facts and engineering data.
339 *Crane Packing Co.

Selector, Motor......New 12-page Bulletin B-2103-1 gives full information on how to select a.c. motors for specific applications. Free for the asking it is a highly valuable tool for any motor user.
440C Reliance Electric & Eng. Co.

Starters, Combination......Square D Combination Starters save space and time. Mount and wire one device instead of two . . . neater, more attractive installations. Complete details available in Bulletins 8538 and 8539.
293 *Square D Co.

Starters, High Voltage ...... Bulletin 8130-F discusses compact, self-contained new starter furnished complete with control transformer to supply low voltage for pushbutton circuits. Mounts against wall or back to back.
440D Elec. Controller & Mfg. Co.

* From advertisement, this issue

Starters, Motor......Built in wide range of ratings for squirrel-cage, wound-rotor & Synchronous motors . . . for full or reduced voltage . . . reversing or non-reversing. Details in Bulletin No. 14B6410B.
121 *Allis-Chalmers Mfg. Co.

Starters, Motor......New line of high-voltage combination starters for squirrel-cage, wound-rotor and synchronous motors described in 12-page bulletin No. 2-850. Increases overload and short-circuit protection.
441A Federal Pacific Electric Co.

Starters, Oil-Break......EC&M oil-break starters are specifically designed for dusty, corrosive atmospheres. Quickly installed because starters are shipped with all internal wiring complete. See Bulletin 8130-CH.
205 *Elec. Controller & Mfg. Co.

Turbines, Solid-Wheel......Feature reliable, trouble-free operation. Rugged construction and superior design result in savings by keeping maintenance costs down to a minimum. Full details in Bulletin No. S-116.
132 *Terry Steam Turbine Co.

Handling & Packaging

Conveyors, Airstream......Plastics, foods, chemicals and pharmaceuticals whose purity must be protected can be conveyed in bulk swiftly and safely with Dracco airstream conveyors. Full details available in Bulletin 529.
92 *Dracco Corp.

Conveyors, Bag......Bulletin 0456 gives details on adjustable-length, flat-belt conveyor designed to convey packages. Covers installation and operation, standard components and various drives.
441B Richardson Scale Co.

Conveyors, Gravity and Power......Bulletin 64 gives up-to-date detailed information on twelve standardized conveyor units. Equipment speeds handling of unit materials in warehouses, and various plant operations.
441C Standard Conveyor Co.

Feeders......Manzel chemical feeders are simple in design, ruggedly built, unfailingly accurate. Adjustable for metering any desired amount of liquid from 0 to 1 gallon per minute. Full details in catalog.
355 *Manzel Div.

Feeders......Prater offers Blow-Thru Feeder for pneumatic systems. Available in cast iron and bronze. Power requirements vary according to the fineness and abrasiveness of the product. New Airlock Catalog P-55.
434 *Prater Pulverizer Co.

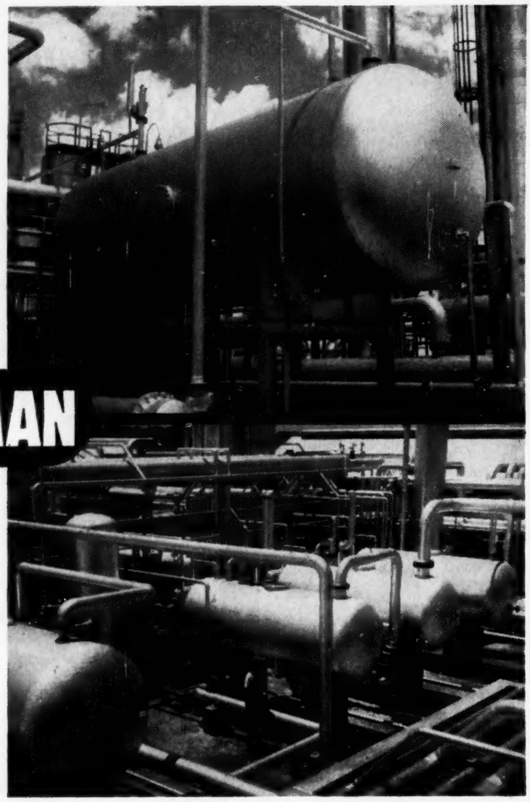
Handling & Processing, Bulk Materials......AJAX Lo-Veyors are available in open pan or booted cover types to safeguard critical processes or formulas against contamination. Full details available in Bulletin 39.
T479 *Ajax Flexible Coupling Co.

Loading Arms, Marine......Chiksan loading arm insures faster tanker turn-around time, promises material savings of lost man-hours due to hose handling injuries, insurance and compensation premiums, etc.
379 *Chiksan Co.

Scales......New Toledo Weight Fact Kit will help you determine how well your scales measure up as a weighing system—show you if any scales are "misfits" in capacity, application or location. Available on request.
366 *Toledo Scale Co.

Scales, Bagging......Bulletin 0256 for new multipurpose, open-type bagging scale discusses construction, operating rates and economy features. Gives full details on standard and optional features of the unit.
441D Richardson Scale Co.

* From advertisement, this issue



LITERATURE . . .

Scales, Weighing and Bagging . . . . . . Leaflet shows line of imported weighing and bagging scales, feeders and closures. Vollenda line of equipment, offering high capacity is said to be known world wide.
442A R & J Textile Corp.

Tanks, Aluminum, Welded......For storage, pressure vessels and processing equipment built to ASME Code specifications to meet all insurance requirements. Company makes available upon request, "Tank Talks."
B478 *R. D. Cole Mfg. Co.

Tanks, Bulk Material......Ideal for buildings with limited headroom. Standard or special sizes available. Low installation cost. For details on bulk material tanks and conveying equipment, Bulletins 529, 549.
438 *Day Co.

Tanks, Storage......Booklet reviews applications, dimensions, capacities, plate specifications and weights for tanks. Discusses manufacturer's facilities, experience with standard and special tanks and vessels.
442B Graver Tank & Mfg. Co.

Tractor-Shovels......The HA "Payloader" and the larger model HAH do the work of four previous units. Ideal for any bulk materials you have to scoop-up, load or spread. Full details made available upon request.
58-9 *Frank G. Hough Co.

Transport Systems, Pneumatic......Illustrated 16 p. brochure details line of pneumatic transport systems. Includes: technical and operating data; installation; application information; etc. Catalog No. 52F.
L466 *Kennedy-Van Saun.

Trucks, Fork......Company offers literature describing Safety Diesel Fork Trucks, which are being used at a growing number of plants where explosive conditions exist. Gives fireproof safety & handling efficiency.
20 Allis-Chalmers Mfg. Co.

Trucks, Fork......Baker "FG" gas trucks feature: heavy-duty industrial truck engine operates at optimum RPM for least strain and abuse; pistons are balanced to grams instead of ounces. Request bulletins.
374 Baker-Raulang Co.

Trucks, Lift......Informative, 24-page booklet was prepared for use as part of operator-training program. Covers operation of lift truck, preventive maintenance, safety and basic materials handling.
442C Hyster Co.

Trucks, Magnesium......Series of ten new product bulletins covers complete line of four-wheel magnesium trucks. Detailed descriptions and specification data on platform, trailer, box and towveyor trucks.
442D Magline, Inc.

Weighers, Gross......Bulletin 0356 describes E-52 gross bagger which weighs and bags in 25 to 100 lb. bags. Photos of scale and components, four schematics of feed arrangements and dimensional drawing.
442E Richardson Scale Co.

* From advertisement, this issue

For the latest developments in
Chemicals
Equipment
Processes
you'll find our "Guide To Technical Literature" right up your alley. You can get any bulletin or catalog in this listing . . . and fast. Simply circle the item's number on the Reader Service Post Card and mail.

Heating & Cooling

Boilers, Water Tube......Vapor Modulatic produces up to 4 hp per sq. ft. of area; develops up to 27 hp per 1000# of weight; produces up to 6 hp per cubic ft. of space used; is a complete package unit. See Bulletin 586.
129 *Vapor Heating Corp.

Burners......Proper utilization of Thermal burner characteristics of high velocity, high temperature, non-luminous flame have obtained remarkable results in furnaces, kilns, ovens and heat exchangers. Bulletin 108.
448 *Thermal Research & Engrg.

Coils, Heating & Cooling......Stainless—Continuous plate type with smooth drawn ferrules pressure-expanded to produce positive mechanical and thermal bond between tube and fin. Full details available upon request.
91a *Marlo Coil Co.

Condensers, Evaporative......Stainless—3-150 tons. Suitable for indor or outdoor location. All prime surface condensing coil. Available to your specifications. Company makes full details available upon request.
91b *Marlo Coil Co.

Controls, Furnace Temperature......Publication GER-1206 discusses basic temperature control systems, thermocouples and control instruments, control elements and special systems for heat treating furnaces.
443A General Electric Co.

Coolers, Impervious Graphite......Details the specifications for all models of the Impervite impervious-graphite cascade cooler. Includes step by step guide for selection of correct model and size for a given job.
443B Falls Industries.

Generators, Steam......If you need 10 to 600 HP and want space-saving, trouble-free service, request information on AMESteam Generators. Company makes complete details available in catalog. Request your copy.
123 *Ames Iron Works.

Generators, Steam......Describe the pre-engineered, standardized steam generators offered in 9 sizes, with capacities of from 50,000 to 150,000 lb. per hr. Includes drawings & design features. Bulletin B-55-4.
67 *Foster Wheeler Co.

Generators, Steam......Vogt steam generators are available in bent tube types and straight tube forged sectional header types for solid, liquid or gaseous fuels. Product bulletins available upon request.
279 *Henry Vogt Mach. Co.

Heat Exchange & Process Equipment......Company offers these types of equipment: condensers, evaporators, jacketed kettles, ribbon mixers, agitators, reactors, pressure vessels, heat exchangers, etc. Bulletin 810.
T480 *Manning & Lewis Engrg.

Heat Exchangers......Complete information on construction materials, sizes and performance are disclosed in Bulletin FH-3 on the Alsotwin fin-tube heat exchanger. Units offer installation flexibility at low cost.
443C Alco Products.

Heat Exchangers......Aero heat exchanger cools liquids & gases by evaporative cooling with atmospheric air, removing the heat at the rate of input, controlling temperature precisely. Bulletins 120 & 124.
332 *Niagara Blower Co.

Heat Exchangers......Revised bulletin presents information about exchanger designed for service with practically all commercial acid, salt and alkaline solutions. Includes selection chart and capacity ratings.
443D Nukem Products Corp.

* From advertisement, this issue

LITERATURE . . .

Heat Exchangers......Describes Type "SSF" stainless steel heat exchangers for heating or cooling liquids & gases as used in industries where elements of corrosion to alloys are encountered. Catalog No. 1155.
462 *Young Radiator Co.

Heat Exchangers, Acid Resistant...... Important data on Swenson type of tube mounting, types of corrosion resistant materials available and advantages of neoprene ring gaskets available in Bulletin SW-200.
39 *Swenson Evaporator Co.

Heat Exchangers, Shell & Tube....... Pyrex brand glass shell and tube units offer these advantages: resistance to corrosion, elimination of foreign material, simplicity of design and easy maintenance. Bulletin PE-33.
284-5a *Corning Glass Works.

Heat Recovery Systems......Digester heat recovery for pulp and paper mills is covered in booklet. Discussion tells advantages of direct-contact condensers and indirect surface condensers for recovering heat.
444A Swenson Evaporator Co.

Heaters, Circulation......Bulletin presents Case Studies concerning the use of Chromalox electric heaters. Includes cases of the heating of fuel oils, steam, air and other gases. Full details in Bulletin F-1587.
82 *Edwin L. Wiegand Co.

Heaters, Gradiation......Makes available detailed literature—"Try the Gradiation Heater for Economical Ethylene Production" and Bulletin 103, "Gradiation Heating for Petroleum and Chemical Processing."
214 *Selas Corp. of America.

Heaters, Liquid....Leaflet presents principles, methods and advantages of liquid heat-transfer media used at low pressure in closed systems. Description serves as a supplement to Catalog 162.
444B S. Morgan Smith Co.

Heaters, Thermal Liquid......Company's thermal liquid heaters offer these advantages: accurate temperature control; high heat transfer rates; low cost, low pressure operation; heat on demand. See Bulletin TLH.
340 *International Boiler Works.

Heating Systems, Dowtherm......Descriptive information on Dowtherm heating systems for processes requiring precision control of high constant temperatures at low pressures, in Bulletin ID-54-5. Request your copy.
136 *Foster Wheeler Corp.

Ovens......Popular throughout the Plastisol industry where uniform temperatures are required. Used to determine curing and baking temperatures, and for batch production of large items. "Ovens for Industry."
349 *Kirk & Blum Mfg. Co.

Towers, Cooling ...... Stainless—2-150 tons. Suitable for indoor or outdoor location. Marlo heat transfer equipment now available to your specifications. Company makes full information available upon request.
91c *Marlo Coil Co.

Towers, Cooling......These two brochures should prove helpful: "Comparative Performance of Cooling Tower Packing Arrangements" and "Answers to 15 Questions about Pritchard Induced Draft Cooling Towers."
130 *J. F. Pritchard & Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking
You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

Towers, Cooling......Detailed specifications complete with dimensioned drawings are shown in Bulletin 5.1.902 on LoLine cooling towers. Structural and mechanical features are illustrated with photographs.
445A J. F. Pritchard & Co.

Traps, Steam......Major reductions in steam trap installation and maintenance work and cost can be achieved by standardization on one make of trap, which, in turn, permits standardized hookups. Steam Trap Book.
389 *Armstrong Machine Works.

Traps, Steam......Give faster, more effective condensate removal. Powerful valves action, positive shut-off, high capacity & each unit service tested. For more details, request new Bulletin No. 10-55.
35 *W. H. Nicholson & Co.

Traps, Steam......New Sarco type TD steam trap is machined from a solid block of stainless steel. Has only 3 parts . . . cap, disc and body . . . and not even a valve-closing mechanism. Full details available in Bulletin 257.
287 *Sarco Co.

Vaporizers, Dowtherm ...... Completely packaged, gas-fired Eclipse Dowtherm Vaporizers give fast, uniform process heating, and their low operating pressures makes them safer. Full details available in Catalog A-100.
344 *Eclipse Fuel Engrg. Co.

Washers, Air......Many of Ducon's maintenance - free centrifugal air washers help transform waste into wallboard. Company makes literature on this and other Ducon efficiency-engineered dust collection equipment.
321 *Ducon Co.

Washers, Air......Stainless steel air washers custom built to your specifications for: washing, cleaning, humidifying, dehumidifying, heating, and cooling. Company makes full details available upon request.
91d *Marlo Coil Co.

Washers, Fume......New Cyclonaire, though only a fraction of the size, offers more fume removal capacity per dollar of cost than any custom-built unit. First complete "Packaged" fume washer. Bul. FW-4.
138 *U. S. Stoneware Co.

Instruments & Controls

Analyzers, Gas......L&N Thermal Conductivity Gas Analyzers feature: accuracy, sensitivity, stability, fast response, interchangeable cells, etc. Company makes complete details available in Folder ND46-91(2).
106 *Leeds & Northrup Co.

Analyzers, Infrared......New brochure deals with Bichromator dispersive infrared plant instrument for measuring single components continuously. Outline of features and specifications, also schematic diagram.
445B Perkin-Elmer Corp.

Analyzers, Thermal Conductivity...... Principle, construction, operation and features of Condu-Therm analyzer and Acratron Electronic recorder in new 12-page color catalog. Special section on gas sampling systems.
445C Hays Corp.

Annunciators ...... Catalog deals with self-policing visual and audible annunciator systems. Gives selection data, wiring for alarms, sample alarm sequences, and other valuable engineering and installation data.
445D Scam Instrument Corp.

Comparators......Fully illustrated, 100 p. tells how to use pH and chlorine control for water supplies, process solutions, production processes in 34 basic industries. Covers complete line of comparators.
L439 *W. A. Taylor & Co.

* From advertisement, this issue

LITERATURE . . .

Computers, Digital......Company is currently compiling a file of new applications and papers on various parts of systems, both industrial and military. This file and periodic additions are made available upon request.
222 *Daystrom Systems.

Computers, Pocket......New type pocket computer is described in booklet "Fascination in Numbers." Not only does device do ordinary slide rule computations but it also solves equations with two variables and constant.
446A Graham Transmissions, Inc.

Computers, Analog......Booklet answers questions on automation and development of control systems. Defines certain types of computers and summarizes applications for each. Lists both virtues and limitations.
446B GPS Instrument Co.

Controllers, Pneumatic Process......Taylor's Transcope Controller offers these advantages: superior performance, exceptional adaptability and simple maintenance. Company offers full details in Bulletin 98278.
24-5 *Taylor Instrument Cos.

Controls, Combustion......Catalog covers complete line of automatic controls and instruments for the combustion industry. It's first time a complete standardized line of this type has been catalogued under one cover.
446C General Controls Co.

Controls, Liquid and Gas......Listing of all major Simplex equipment for measurement and control of liquids and gases. Booklet of 36 pages is a major revision of earlier volume produced in 1953. Request your copy.
446D Simplex Valve & Meter Co.

Controls, Liquid Level......Standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. Request catalog data.
346 *Magnetrol, Inc.

Controls, Power Plant......Booklet 1022A reviews in detail combustion and boiler feed water control, pressure reducing, desuperheating and automatic soot blowing. Equipment available as single package or individual units.
446E Blaw-Knox Co.

Controls, Pressure......Three bulletin pages cover pressure controls—Type H5 in Bulletin 5-5; Type J7 in Bulletin 5-7 and Type J40 in Bulletin 5-9. Cover specification policy, purpose, switch ratings, etc.
446F United Elec. Controls Co.

Controls, Temperature......Model L-18 control covered in Bulletin 106 is used for liquids or gases up to 1,000 F. Discusses differential expansion operation, specification of ranges, tube sizes and accuracy.
446G Burling Instrument Co.

Controls, Temperature ...... Complete Thermoswitch line of temperature controls is covered in catalog MC-135. Gives physical specifications, performance data, temperature ranges, modifications and special features.
446H Fenwal, Inc.

Controls, Temperature......New Model HL15-10 indicating high temperature limit control is a fast-acting, precision limit control for protecting processing operations. Full details available in Bulletin No. 311.
441 *Partlow Corp.

Gages, High Pressure......Strahman high pressure gages are used in refineries and chemical plants throughout the world. Company makes further information available in complete catalog. Request your copy.
L469 *Strahman Valves.

Gages, Pressure & Vacuum......Company makes complete details available on its dial indicating and recording pressure and vacuum gages. SG safety gage feature affords safety both in front and back. Bul. 525A.
L330 *Weksler Thermometer Corp.

* From advertisement, this issue

Gages, Radiation......New radiation gage used with strip-chart recorder is described in data sheet 10.9-3. Device makes continuous non-contact measurement of weight per unit area of sheet materials.
447A Minneapolis-Honeywell.

Gages, Remote Reading......Data unit 291 supplement illustrates and describes new inclined Truscale remote reading gage. Design gives maximum visibility of gage mounted either on high or low installation.
447B Jerguson Gage & Valve Co.

Indicators, Portable......Compact, lightweight unit weighs under 4 lbs. and measures only 4"x5"x6". Yet it has a double scale 23½ inches long. Company makes further information available in Bulletin 64-E.
B475 *Thermo Electric Co.

Instrument Systems......Attractive 20-page booklet "Your Next Move for Profit and Progress" shows how various members of Consolidated group and their instruments can reduce the guesswork in doing business.
447C Consolidated Electrodynamics.

Instrumentation, Electronics...... The Batchetron is . . . Fairbanks-Morse electronics instrumentation plus accurate weighing in the Fairbanks-Morse tradition. New bulletin gives many suggested applications. Bul. ED-14.
112 *Fairbanks-Morse & Co.

Instruments, Dewpointer......Alnor Dewpointer makes it easy to achieve consistent accuracy. Means faster readings with no time lost calculating variables. Complete details available in Dewpointer Bulletin.
R466 *Illinois Testing Labs.

Manometers......Norwalk manometers meet the requirements for a sturdy dependable gage that will stand abuse and rough handling without breaking. Service and Universal types have unbreakable plastic tubes. Bul. 3100M.
447D Norwalk Valve Co.

Meters, Flow......1700 Series Flowrator meter and all-metal Fig. 52 armored Flowrator meter give you a predictable calibration performance in all ranges doing away with necessity of individual calibration.
159 *Fischer & Porter Co.

Meters, Flow......Multi-valve Fluidometer installations are available either jacketed or unjacketed and are "tailor-made" to fit the particular job. Company makes details available in Bulletin F1-56.
B479a *Hetherington & Berner.

Meters, Turbine Flow......Flow metering systems based on bearingless turbine type flowmeters are discussed in 6-page leaflet. Other elements in system are converters, totalizers and recorders.
447E Potter Aeronautical Corp.

Pyrometers, Portable Potentiometer...... Model 9B improved Pyrotest is only portable potentiometer pyrometer with interchangeable direct-reading scales. Checks and calibrates thermocouple temperature instruments.
447F Technique Associates.

Recorders, Pulp Brightness......Data sheet 29.5-2 tells to apply Brown's Electronik instrument to record and control bleaching of paper pulp through measuring brightness continuously with Allegany meter.
447G Minneapolis-Honeywell.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking
You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

LITERATURE . . .

Recorders, Temperature and Pressure ......Brochure 1021 describes workings and advantages of filled-tube system recorders. Illustrations include blueprints that show makeup, installation and operation.
448A Burgess-Manning Co.

Regulators, Temperature ...... Foster manufactures a complete line of regulators for use in power or process plants, laundries and business buildings—for hot water storage heaters, ovens, driers, etc. Bul. T-101.
R455 *Foster Engrg. Co.

Regulators, Temperature ...... Fulton Sylphon No. 999-T temperature regulator provides the accuracy and simplicity that mean lower first costs—lower maintenance costs—and lower processing costs. See Catalog D-EC.
61 *Fulton Sylphon Div.

Relays, Speed Sensor......Relay that allows use of speed as a controlling quantity is shown in Bulletin SSR-2.1. Starts cycles automatically after preset speed is reached. Also used as over or under speed limit.
448B Machinery Electrification.

Regulators, Self-Operated ..... Bulletin C-655 describes Series 655 self-operated regulators that control pressures of water, steam, oil, gas or other fluids. Regulators also used as air-operated shutoff valves.
448C Fisher Governor Co.

Rotameters......New bypass rotameter measures high fluid flow rates in pipes above 2-in. size. It eliminates need for overload checks, seal pots and equalizing valves. Details in new Bulletin 116. Available upon request.
448D Brooks Rotameter Co.

Transmission Systems, Pneumatic...... Laminair pneumatic transmission system discussed in Bulletin 750 provides a sensitive and accurate type of instrumentation. Output pressure varies directly with fluid flow.
448E Simplex Valve & Meter Co.

Transmitters, Pressure......Style H electric transmitter for low differential pressure discussed in new bulletin 501. Illustrations show construction, dimensions and operation. Small differentials measured without hysteresis.
448F Burgess-Manning Co.

Variators, Speed......Cleveland speed variator gives stepless speed over a full 9:1 range—from 1/3 to 3 times input speed. Output speed can be adjusted by either a hand wheel or by automatic remoe control. Bul. K-200.
12 *Cleveland Worm & Gear Co.

Viscometers ...... Industrial instrument measures viscosity of materials under actual process conditions. Design based on principle that's been proven and accepted in laboratory instrument. Four-page descriptive bulletin.
448G Brookfield Engineering Lab.

Pipe, Fittings, Valves

Adapters, Tube Fitting......New 12-page catalog 4360 shows straight thread plugs and adapters, O-rings for straight thread fittings and steel and brass pipe fittings. Specifications tabulated for each part.
448H Parker Appliance Co.

Coils......Type "R" coils are specially designed for installations where frequent mechanical cleaning of the inside of the tubes is required. Complete drainability, easily cleaned, high heat transfer. Catalog R-50.
334 *Aerofin Corp.

Couplings, High Pressure......Snap-Tite design seals lines positively and automatically when you disconnect, opens to full, free flow when you connect. Both operations done instantaneously. Cutaway dwgs., engineering data.
448I Snap-Tite, Inc.

* From advertisement, this issue

Couplings, Pipe......Now approved by the Underwriters' Laboratories for hazardous fluids is the all-steel Quik-Joint pipe coupling. No pipe threads needed. Good for pressures to 2,000 psi. Details in bulletin.
449A Guardian Products Corp.

Fittings, Flareless Tube......Catalog 4320 covers flareless type Ferulok tube fittings with the visible bite that is especially suitable for heavy wall tubing. Includes fittings to mount new SAE straight thread boss.
449B Parker Appliance Co.

Fittings, Hose ...... Catalog 4431 describes reusable Hoze-lok fittings used with cotton-covered single-wire-braid hose for Freon 12 service. Fittings with male pipe threads, 45 deg. or 37 deg. flare nose or swivel nut.
449C Parker Appliance Co.

Fittings, Stainless & Alloy Steel...... When heat or corrosion add to your pressure piping problems, protect pipe joints with . . . forged stainless or alloy steel fittings. Full details available in Bulletin S-1-55.
450 *Watson-Stillman Fittings.

Fittings, Vacuum Conveyor......Vacu-Flo fittings and tubing for vacuum systems and lines conveying liquids, gases and solids provide maximum load capacity and top performance. Details in 6-page bulletin.
449D H-P Products.

Flanges, Back-Up......Line of forged carbon steel back-up flanges have found wide acceptance in stainless and other alloy piping installations of lightwall pipe. Request flange dimensional slide rule and catalog.
347 *Camco Products.

Flanges, Insert......Sifco stainless insert flanges offer flexibility of installation, lower maintenance, fewer replacements. They eliminate the problem of bolthole alignment. Request full details and catalog.
R465 *Stainless Insert Flange Co.

Guide, Valve Selection......Now available, newly revised edition of "Guide for Selecting Valves, Boiler Mountings, Lubricating Devices." For easy reference, 24 pages of tables and data are completely indexed.
449E Lunkenheimer Co.

Hose, Metal, Flexible......Produced in various alloys of stainless steel—in monel, bronze, and carbon steel. Ideal for use with high temperature and high pressure corrosive gases. Full details in Bulletin 21-A.
63 *Atlantic Metal Hose Co.

Hose, Metal, Flexible......Engineered and manufactured to absorb the costly beating your piping system is now taking . . . efficiently and economically. Company makes details available in Bulletin IND 4.
431 *Packless Metal Hose.

Hose & Tubing, Metal, Flexible......New catalog simplifies selection and ordering of metal hose and tubing for industrial equipment and maintenance applications. Complete details available in Catalog G-560.
213 American Metal Hose Div.

Nozzles, Spray......Company provides a 48 p. industrial catalog with full data on thousands of standard and special nozzles—for every type of spraying. Also information on related equipment. Catalog No. 24.
T474 *Spraying Systems Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking
You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

LITERATURE . . .

Pipe, Corrosion Resistant......Bulletin gives dimensions, weights and bursting pressures for Schedule 40 and 80 PVC pipe. Available in both unplasticized and high-impact PVC. Installation instructions.
450A H. N. Hartwell & Son.

Pipe & Fittings, Jacketed......Bulletin discusses standard jacketed fittings for maintaining uniform temperature (hot or cold), jacketed spring loaded plug valves, jacketed welded steel fittings, etc. See Bulletin J-56.
B479b Hetherington & Berner.

Pipe, Hard Rubber......Heat-resistant nitrile hard rubber pipe handles inorganics at 250-275 deg. F . . . also resists wide range of organic chemicals at room temperature. For details, see Bulletin 96-A.
326a *American Hard Rubber Co.

Pipe, Plastic......General-purpose moderately priced rubber-plastic pipe handles most common chemicals to 170°F . . . except few strong acids & organic solvents. Tough, odorless, tasteless. Bulletin No. 80.
326e *American Hard Rubber Co.

Pipe, Polyvinyl Chloride......Describes Ryertex-Omicron PVC rigid type unplasticized pipe. Gives engineering data on pipe & lists over 200 chemicals it will convey without being attacked. Technical Bulletin No. 80-3.
277 *Joseph T. Ryerson & Son.

Pipe, Rigid......Koroseal rigid pipe is exceptionally easy to install. Can be threaded with standard pipe threading equipment, quickly joined to Koroseal valves and fittings. Full details available in booklet.
19 *B. F. Goodrich Industrial.

Pipe, Saran Lined......Saran lined pipe, fittings and valves cut corrosion costs . . . can be cut in the field with available pipe fitter's tools. Liquid never touches metal in saran lined pipe. Request details.
137 *Saran Lined Pipe Co.

Thermopiles......Conversion of infrared energy into electrical energy that is suitable for amplification and measurement by means of thermopiles is described in a new 12-page brochure. Used in temperature control devices.
450B Jarrell-Ash Co.

Traps, Compressed Air and Gas......Entirely new type of compressed air and gas trap described in Bulletin 501. Trap combines magnetic, pneumatic and automatic action. Pressure range of trap is 10 to 200 psig.
450C Hankison Corp.

Tubes, Cabled......12 p. technical bulletin describes cabled tubes for instruments & controls, titled "Crescent Armored Multitube System". Describes types of Multitube & methods of installation. Bulletin 356-H.
T473 Crescent Insulated Wire.

Tubing, Condenser & Exchanger...... Offers four tubes for process condensers and exchangers handling heavy concentrations of hydrogen: arsenical admiralty, arsenical aluminum brass, arsenical muntz, duplex.
303 *Bridgeport Brass. Co.

Valves......There's an Ace hard rubber, rubber-lined, or plastic-lined valve for every corrosion application. Diaphragm, gate and check types. Lists chemicals handled in Bulletin CE-52. Request your copy.
327b *American Hard Rubber Co.

Valves......Line of steel valves feature dependable operation and low maintenance cost. Gate, globe and check types handle the most severe high-pressure, high temperature services. Full details in Catalog 20.
380 *Chapman Valve Mfg. Co.

Valves......Features: non-sticking; no metal-to-metal contact; needs no lubrication; requires no packing; renewable sleeve & plug. Details on type F valves are available. Request a copy of Bulletin V/4b.
305 *Duriron Co.

* From advertisement, this issue

Valves, Air Release......Heavy duty air release valves for pressures up to 500 lb. are shown complete with specifications and capacities in Bulletin 856. Outstanding features assure leakproof service.
451A V. D. Anderson Co.

Valves, Ball......Double-seal ball valve constructed entirely of PVC is described in new bulletin. It's first all PVC valve offered complete with air operator for remote control and sequence operations.
451B Jamesbury Corp.

Valves, Butterfly......Rubber lining of R-S butterfly valves protects entire valve body, gives you corrosion resistance with maximum economy. Complete SMS line to meet your fluid control problems. Request data.
350 *S. Morgan Smith Co.

Valves, Control......Super 70 Series control valves offer: accurate response from topworks; greater stability through valve; self-actuating closure with float ring. Company makes details available in Catalog 70-11.
79 Black, Sivalls & Bryson.

Valves, Diaphragm Packless......New, compact valve recommended for vacuum and refrigeration service and control of hazardous and expensive fluids is described in Bulletin 101-B. Connections either flare or O.D.S.
451C Henry Valve Co.

Valves, Fittings & Flanges, Drop Forged Steel......See 400 p. catalog for complete line of drop forged steel valves, fittings, and flanges for oil, steam, water, air, gas, & refrigeration services. Cat. F-9.
236 *Henry Vogt Machine Co.

Valves, Gate......Crane 33XL cast steel gate valves are tough enough to withstand hot, corrosive liquors. Body seat rings, liners and flange faces are 18-8 SMo alloy, integrally welded. "Valve Performance Facts."
233 *Crane Co.

Valves, Gate......Crane Ni-Resist alloy cast iron gate valves have substantially greater resistance to corrosion, erosion and wear than ordinary cast iron valves, yet cost very little more. See Circular AD-2047.
397-8 *Crane Co.

Valves, Gate......Darling gate valves are made in metals, types and sizes for most services . . . and for pressures up to 1500 pounds. Feature fully revolving double disc parallel seat principle. Bulletin No. 5003.
338 *Darling Valve & Mfg. Co.

Valves, Lubricated Plug......Low friction Teflon washer permits spring to turn with plug. Means less maintenance and longer life are assured, because spring is subjected to compression only. Book 39—Section 5.
99 *Homestead Valve Mfg. Co.

Valves, Needle......The Marsh needle valve is now available in 416 stainless steel throughout. It is guaranteed for working pressure up to 10,000 psi. For complete details, request Bulletin No. NV-2.
T472 *Marsh Instrument Co.

Valves, Packless......Complete line of packless valves to handle hazardous liquid and gas is described in 22-page bulletin. Detailed data for specifying and ordering, application and selection charts.
451D Robertshaw-Fulton Controls Co.

Valves, Relief and Back Pressure...... Top works of new line of relief and back pressure valves are protected by Kel-F thermoplastic diaphragms. Can be used with corrosives up to 1,500 psi. and 250 F. Bulletin 1255-B.
451E Milton Roy Co.

Valves, Solenoid......New ASCO solenoid valve has only three operating parts. Offers these advantages: simplicity in operation, up to 400 cycles per minute, converts in 30 seconds. Full details available in Bulletin 8316.
391 *Automatic Switch Co.

* From advertisement, this issue

Process Equipment

Activated Charcoal Systems......Comprehensive catalog shows how activated charcoal is used to recover air and solvent, remove odor, purify air, preserve food. Complete line of equipment discussed in detail.
452A Barnebey-Cheney Co.

Agitating Equipment . . . . . . Use Nettco Flomix to combine liquids and solids as they flow through a pipe line. Also offer side entering and portable and tripod models. Company makes available details in Bulletins 531, 532, 551.
62 *New England Tank & Tower.

Blenders-Filters-Meters . . . . . . Bowser metering controls inventory; filtering improves quality; blending saves manhours. Company makes complete details available in "Digest." Request your copy.
B476 *Bowser, Inc.

Blenders, Twin Shell......Standard model Twin Shell for gentle mixing action, "Intensifier" for difficult-to-blend materials, "Liquid-Solids" blender for blending liquids into dry materials. See Catalog 14.
189 *Patterson-Kelley Co.

Centrifugals......A Reinveld Centrifugal can reduce your Thermal Dryer requirements as much as 64% over conventional filtration methods. Capable of handling 1200 gallons per hour of feed slurry. Bulletin RC356.
169a *Heyl & Patterson.

Centrifugals . . . . . . Batch-Master offers choice of perforate and imperforate baskets . . . corrosion-resistant materials . . . manual unloader if desired. Further information available in Bulletin TC-14-56.
430 *Tolhurst Centrifugals.

Classifiers......H & P Cyclones are standard in stainless steel or with rubber-lined aluminum or carbon steel bodies. Capable of handling as little as 8 GPM, with no upper limits. Details in Brochure C-954.
169b *Heyl & Patterson.

Collectors, Sludge......Circulating Collector accomplishes positive movement of sludge, along the most direct path to the draw-off, in the shortest time. Company makes complete information available in Book No. 1982.
452B Link-Belt Co.

Copying Machines......You can save time and money with the all-electric 1957 Apeco Dial-A-Matic Auto-Stat. New special report gives the results of a thorough study of engineers' copying requirements. Also free book.
71-2 *American Phtotocopy Equip. Co.

Crushers......Model WC Crusher . . . efficient controlled reduction for scores of industries, hundreds of materials. Equipped with rolling rings or hammers. Minimum headroom. Request complete literature.
B473 *American Pulverizer Co.

Crushers, Gyratory......New TF gyratory crusher which produces a big volume of fine product is covered in Bulletin 127. Outstanding features outlined and illustrated. Table of sizes and approximate capacities.
452C Traylor Engrg. & Mfg. Co.

Dehydrating Systems, Caustic......Booklet SW-203 tells how system cuts installation and operational costs to less than one half those for a comparable pot-type system. Flow sheet details components and features.
453A Swenson Evaporator Co.

* From advertisement, this issue

Drag Scrapers......No personnel need enter the storage area; a single operator can recover material from all sections by remote control. Operating costs quoted as low as 2.1 cents per ton for labor, etc.
360 *Sauerman Bros.

Dryers.......Offer a variety of dryer models to meet all problems. Designed to dry air, gases or liquids to sub-zero dew points at low cost. Constructed of quality materials. For details, see Bulletin D-100.
127 *C. M. Kemp Mfg. Co.

Dryers......Lectrodryers can dry air and gases in volume to dewpoints below —100°F—can drop relative humidity lower than 10%. "Because Moisture Isn't Pink" describes drying installations in many industries.
68 *Pittsburgh Lectrodryer Co.

Dryers......Standard Hersey Dryers handle difficult drying jobs with trouble-free, efficient and economical service. Feature good design, quality materials and skilled workmanship. See Standard Hersey Bulletin.
167 *Standard Steel Corp.

Dryers, Rotary......Company recommends the Roto-Louvre wherever sensitive materials are to be precessed. Useful when there's a problem of overheating, breakage, variation of particle size or floor space. Book 2511.
133 *Link-Belt Co.

Dryers, Vacuum, Rotary......Company offers Catalog 720 on "Vacuum Drying" . . . and Bulletin 640 on how the Stokes Advisory Service and Laboratory can help you. Company makes both bulletins available upon request.
44-5 *F. J. Stokes Corp.

Dust Collectors......Dust Control for Industry encompasses in 16 pages the complete range of dust control equipment and accessories. Discusses importance of control, standards and efficiency.
453B Pangburn Corp.

Dust Filters......Sly dust filters offer important advantages in greater filtering capacity, space-saving installation, automatic control, easier bag replacement. Full details made available in Bulletins 98 and 102.
451 *W. W. Sly Mfg. Co.

Feeders, Self-powered ...... Technical Bulletin TP-68-M presents details about new self-powered feeder that controls feed of dry, free-flowing materials at rates from 200 to 2,000 lb. per min. Operating range 10 to 1.
453C Wallace & Tiernan, Inc.

Filter Fabrics......The right fabric adds efficiency to continuous operation. Announces availability of a fully illustrated booklet. "Filter Fabric Facts," describing filter fabric development and application.
217 *Wellington Sears.

Filter Leaf......New "RIM-LOK" Filter Leaf provides simple closure of metal filter cloth in leaf frame without use of rivets, bolts or solder. Made of any commercial alloy. Full details in Bulletin No. 571.
456 *Multi-Metal Wire Cloth Co.

Filters......Cuno offers a complete line of filters including Micro-Klean . . . double life replaceable cartridges; higher flow rates in less space; consistent, uniform filtration. Details available in Bulletins.
440 *Cuno Engrg. Corp.

Filters, Condenser......Bulletin covers construction, operation and specifications of Hankison's Condensifilters. They are efficient in operation, rugged in construction and easy to service. See Bulletin M-7155(R).
453D Hankison Corp.

Filters, Dehydrator......Dehydrafilters are designed specifically for single, isolated installations of pneumatic instruments and controls requiring small volumes of compressed air. Full details in Bulletin 302.
454A Hankison Corp.

* From advertisement, this issue

Filters, Flow......Nugent full flow filters will remove foreign solids as small as 2 microns from lube or fuel oil before they can reach and damage vital precision parts. Full details in free descriptive literature.
348 *Wm. W. Nugent & Co.

Floats......Harris Floats for any liquid, for high pressures, for high temperatures. Catalog presents data on various sizes, types of floats, and suitable metals for different corrosive liquids, temperatures.
BL471 *Arthur Harris & Co.

Impervious Graphite Equipment......Report helps estimate cost and select impervious graphite processing equipment. All standard models illustrated. Included in 32 pages are details of impervious graphite material.
454B Falls Industries.

Kiln Chain Systems......For wet process kilns in cement, paper and chemical industries, new chain system is more resistant to wear, corrosion and heat. Illustrated bulletin shows how to use various components of system.
454C Allis-Chalmers Mfg. Co.

Kilns, Rotary......Made for the individual installation, Traylor rotary kilns have been built to 12'0" in diameter and to 450'0" in length. Company makes complete details available in Bulletin 11-121. Request your copy.
372 *Traylor Engrg. & Mfg. Co.

Liquid Handling Equipment......Offers complete unit designed to do your job efficiently—pump, motor and control, with pump and motor mounted on a single base plate for quick and easy installation. Bul. 25C6177.
22-3 *Allis-Chalmers Mfg. Co.

Low Temperature Equipment......New items included in new 16-page catalog include liquid oxygen and nitrogen in-plant transportation and storage units as well as highway units and vaporizers. Illustrations, charts.
454D Hofman Laboratories.

Mills......Mills for every application are listed in 6page bulletin. Includes tricone, rod, cylindrical, tube, batch, conical and disk mills. Also covers grinding mill accessories and list applications.
454E Hardinge Co.

Mills, Hammer......New long-life, quick-change screens are outstanding feature of new hammer mill. Life of screens has been increased ten fold and capacities are higher. Assembly dwg., specifications, dimensions.
454F Strong-Scott Mfg. Co.

Mills, Roller......Positive and continuous precision size control at exceptionally high production rates are but two of the numerous features of Williams Roller Mills. Request fully descriptive new Catalog.
75 *Williams Patent Crusher.

Mixers, Chemical......Bulletin covers the Shear-Flow Mixer: for mixing, homogenizing or dispersing; up to five times faster; counter-rotating impellers; reduces agglomerates and particle size; no operating torque.
454G Gabb Special Products.

Mixers, Laboratory......You get as much as 20 years' service from a Lightnin Laboratory Mixer. Can run Model F at any speed up to 1600 RPM. Four other models to choose from. Full details available in Bulletin B-112.
157d *Mixing Equipment Co.

Mixers, Portable......Use in industry reduces costs, saves time, labor and secures better and more refined products. Catalog includes data on construction, dimensions, specifications, etc. 28 p. Bulletin B-108.
157c *Mixing Equipment Co.

Mixers, Side Entering......Furnishes detailed information on features, typical applications, mechanical design, maintenance, shaft seals, methods of installation, etc., in completely illustrated Catalog B-104.
157b *Mixing Equipment Co.

* From advertisement, this issue

LITERATURE . . .

Mixers, Top Entering......Makes available pertinent information on top-entering mixers (propeller type) . . . for closed tanks, pressure & vacuum . . . for open & loose-covered tanks. Data in Catalog No. B-103.
157a *Mixing Equipment Co.

Mixing & Homogenizing Equipment...... Eppenbach colloid mills, homo-mixers and agi-mixers—their unique features and scores of uses—are fully described in comprehensive new catalog. Request Eppenbach Fact Book.
R467 *Gifford-Wood Co.

Polymerizers, Glassed Steel......Bulletin outlines the latest advances and accessories available in line of glassed steel polymerizers. Standard design rates up to 350 F. from vacuum to 150 or 200 psi.
456A Pfaudler Co.

Presses, Filter......Offer numerous features: lowest cost per sq. ft. of filtering area; produces perfect clarity of filtrate; can be used in decolorizing—deodorizing; etc. "Guide to Better Filtration."
433a *T. Shriver & Co.

Process Equipment......Your guide to corrosion-free process equipment. 80 pages are packed with information on the behavior of aluminum. "Process Industries Applications of Alcoa Aluminum."
50-1 *Aluminum Co. of America.

Process Equipment......Manufacturing techniques that achieve a high degree of efficiency allow you to purchase Day equipment economically . . . mixers, sifters, blenders, roller mills, pilot plant equipment. See Catalog.
333a *J. H. Day Co.

Process Equipment......New general catalog gives manufacturers entire line of materials handling, process equipment and services. Includes description of engineering facilities to help solve customer problems.
456B Gen. American Transportation.

Process Equipment......Pipe and fittings, towers, tanks, pumps, valves, nozzles, filters, etc. now can be manufactured from Chemplas 15, a mixture of furan resin and inert ceramic. Resists corrosives and high temperature. 4 pages.
456C General Ceramics Corp.

Process Equipment......Sprout-Waldron installations achieve a degree of specific fitness that is unusual in industry. Offers bulletin on equipment & systems for processing dry & semi-dry materials. Bulletin 95.
89 *Sprout-Waldron

Processing Equipment, Liquid......Written for plant personnel, Alsop's new 40-page catalog contains photos, diagrams and comprehensive information on entire line of stainless-steel liquid processing equipment.
456D Alsop Engineering Corp.

Reactors, Nuclear Research......Characteristics and uses of three research reactors are described in Bulletin GEA 6326-B. Specific uses, design details, safety features and experimental facilities are covered.
456E General Electric Co.

Reactors, Stainless Steel......Pfaudler designs include such features as—heavy duty drives, properly engineered agitation systems, rotary seals or stuffing boxes, baffles, thermometer wells, etc. See Brochure 944.
488 *Pfaudler Co.

Screens, Vibrating......Vibrating screens for fast, accurate dry screening of light or fine materials. Sizes closely through small screen openings; screens corrosive and toxic chemicals safely. Request Book No. 2377.
456F Link-Belt Co.

Scrubbers, Conical......Completely revised edition, Bulletin 37-B completely describes scrubber. Includes ratings and dimensions as well as approximate operating capacity. Unit used for treating or beneficiating ore.
457A Hardinge Co.

* From advertisement, this issue

Separators, Air......Controlled centrifugal whirl by balancing forces separates rapidly, efficiently, cement, lime, clay, talc, ceramics, refractories, phosphates, coal & many other materials. Bulletin No. 087.
65 *Sturtevant Mill Co.

Separators, Drum......Stearns drum-type magnetic separators protect your product—purify it by removing contaminating iron; protect your plant from spark-induced explosions. Full details in Bulletin 93EB.
378 *Stearns Magnetic Mfg. Co.

Separators, Entrainment......If liquid entrainment is a contributing factor in design or operation, Metex Hi-Thruput Mist Eliminators will assure greater production, improved quality of yield and reduced costs. Bul. ME-6.
435 *Metal Textile Corp.

Storage Equipment, Chemical......Lightweight, nonconductive, temperature-resistant tanks by Beetle have proven tops at beating costly chemical corrosion problems. Company offers fully descriptive literature.
322 *Carl N. Beetle Plastics.

Strainers......Yarway fine screen strainers protect equipment, prevent dirt, scale, chips, welding dross, etc. from reaching working parts. Screen is easily removed for cleaning. Full details in Bulletin S-204.
377 *Yarnall-Waring Co.

Thickeners......Spiral rakes of the Hardinge thickener compress solids to maintain high density of underflow. "Auto-Raise" drive mechanism prevents overloading as the underflow is thickened. See Bulletin 31-D-11.
320 *Hardinge Co.

Washers, Centrifugal Air......Operation, installation and diversified applications of the Ducon centrifugal air washer are described in fully illustrated bulletin W-7456. Unit handles wide range of dust removal jobs.
457B Ducon Co.

Wire Cloth......80 p. catalog describes company's facilities for fabricating wire cloth parts. Wire cloth parts for screening, filtering and special uses. Provides useful metallurgical data. Request your copy.
449 *Cambridge Wire Cloth Co.

Wire Cloth......Wire cloth made of all malleable metals such as aluminum, brass, bronze, phosphor bronze, copper, monel, Nichrome, nickel and stainless steel. Company makes details available in Catalog E.
453 *Newark Wire Cloth Co.

Pumps, Blowers, Compressors

Compressors ...... Describes Allis-Chalmers single and two-stage vane type compressors for shop air, gas handling, drilling and numerous other applications . Request Bulletin Nos. 16B8244 and 16B8126.
227 *Allis-Chalmers Mfg. Co.

Compressors, Air......Data sheet lists construction details, specifications, and models of air compressors in the ¼-20-hp. range. Helps you select the right compressor for a specific job in virtually any industry.
457C Brunner Mfg. Co.

Compressors, Oil-Free......Joy WG-9 oil-free compressors are equipped with carbon graphite piston rings. Need no lubrication, and compensate automatically for wear. For further information, request Bulletin 104-11.
7 *Joy Mfg. Co.

Eductors......Recently added line of unplasticized PVC eductors are used to pump and mix liquids and are particularly good for corrosives. Leaflet shows recommended uses and additional pertinent information.
458A Schutte & Koerting Co.

* From advertisement, this issue

Eliminators, Static......Design and operation of Ionotron radioisotope-activated static eliminator is presented in Bulletin L/A 2778. Diagrammatic sketch shows the effective zone of device during operation.
458B U. S. Radium Corp.

Fans . . . . . . Mechanical efficiency above 78% over a broad range—high volume, high pressure characteristics, also high resistance to abrasion. Type CR Fans are discussed in detail in Bulletin No. FD-205.
88 *Buffalo Forge Co.

Fans, Centrifugal . . . . . . Performance charts on a line of backward curved blade centrifugal fans are featured in a new 60-page illustrated brochure, C-103. Suitable for either belt or direct drive.
458C Chicago Blower Corp.

Pumps . . . . . . Available in aluminum, bronze, stainless steel, Hastelloy and titanium, Aldrich fluid ends handle all types of liquids—nitric acid, caustic solutions, fatty acids, etc. Full details in Data Sheet 100.
108 *Aldrich Pump Co.

Pumps......Ingersoll - Rand motorpumps have well-balanced impellers and precision machined parts help provide peak performance and smooth operation on every job. Request the latest Motor pump Catalog for details.
R439 *Ingersoll-Rand.

Pumps......Modern Type PR center-line mount packing gland pump design for temperatures up to 850° F. and Modern Type PRS center-line mount mechanically sealed pump design for temperatures up to 250° F. Bul.B-1605.
119 *Peerless Pump Div.

Pumps......Company offers two types of pumps for volume pumping and for great pressure . . . single-stage and double-stage. See Bulletins 721.6 and 720.4 for single-stage pumps, Bulletin 722.6 for double-stage pumps.
437 *Goulds Pumps.

Pumps......Handl[illegible]ost anything that can pass throu[illegible] a pipe, from free-flowing liquids [illegible] non-pourable pastes—materials containing relatively large particles or abrasives. Details in Bulletin 30-CE.
83 *Robbins & Myers.

Pumps......Taber pumps are built for handling chemical solutions, efficiently and economically . . . in the processing industries. Details on horizontal pumps in Bulletin C-355, and vertical pumps in Bulletin V-837.
R464 *Taber Pump Co.

Pumps......If you have a problem where metering, blending or other accurate pumping of liquids is concerned, let Viking help solve it. Use Viking pumps for accurate pumping. For information, request Bulletin 57Sc.
B472 *Viking Pump Co.

Pumps......Warren can build the pump to do the job . . . 50 SSU or 500,000,000 SSU. Offers these types of pumps—reciprocating, centrifugal and gear-screw. Company makes full details available in bulletins.
353 *Warren Pumps.

Pumps, Acid . . . . . . Mighty midget for pumping acids. Jabsco neoprene-impeller pump made of Ace hard rubber outlasts, out-pumps anything in its pressure, size and price class. Full details in Bulletin No. 97-A.
326-b *American Hard Rubber Co.

Pumps, Acid......On most difficult pumping jobs...dependable highly efficient pumps deliver continuous, trouble-free performance on round-the-clock schedules wherever they are installed. Full details.
369 *A. R. Wilfley & Sons.

Pumps, Centrifugal......Complete line of off-the-shelf, high-speed centrifugal pumps are described in 6-page bulletin P-3b and insert P-3c. Pumps are available in a range of materials to combat corrosion, erosion, wear.
459A Ampco Metal.

* From advertisement, this issue

Pumps, Centrifugal......Easily adapt to changing conditions and demand, save power, combat corrosion and erosion. Speeds, 1750 & 3500 rpm; capacities to 600 gpm; heads to 300 ft. Request Bulletin P-3C for details.
446 *Ampco Metal.

Pumps, Centrifugal......Full details on company's modern, efficient units are contained in complete Tri-Clover Sanitary Pump Catalog 253. Provide greatest possible degree of corrosion-resistance and sanitation.
383 *Tri-Clover Div.

Pumps, Centrifugal......From impeller to shaft seal . . . Weinman pumps are built better. The built-in quality adds up to cost-saving, pumping efficiency for every job. Request descriptive product Bulletin.
361 *Weinman Pump Mfg. Co.

Pumps, Centrifugal......Choice of mechanical seals — or packing — with Standard End Suction Centrifugal pumps. Can easily convert from one to the other using standard stock parts. Full details in Bulletin W-300-B4B.
56-7 *Worthington Corp.

Pumps, Chemical......Heavy duty chemical pumps designed for long service life with minimum maintenance are discussed in Bulletin P-9a. Instructions given in bulletin can assure best possible service.
459B Duriron Co.

Pumps, Double Suction . . . . . . Hydraulically balanced, highly efficient and durable, in sizes to deliver from 10 to 14,000 gpm for circulating, air conditioning, other plant services. Details in Bulletin 955.
126 *Buffalo Pumps.

Pumps, High Vacuum . . . . . . Catalog covers: industrial and scientific applications, types of vacuum systems, operating mechanism, vibration elimination, gas ballast, discharge valves, etc. Request Catalog 425.
183 Kinney Mfg. Div.

Pumps, Industrial......Jabsco Industrial Pumps: instantly self-priming; simple, compact, only one moving part; durable neoprene impeller; self-lubricated; trouble-free operation. Catalog sheets available.
T478 *Jabsco Pump Co.

Pumps, Liquid, Rotary......Bulletin presents: vacuum pumps, pumping information, strainers, heliquad pumps, pump drives, rotating plunger pumps, history and representative types. Request Bulletin No. L51A.
459C Kinney Mfg. Div.

Pumps, Piston-Diaphragm......For controlled-volume pumping of fluids. Flow-charts, typical applications, description and specifications and models of various capacities and constructions in Bulletin No. 440.
85 *Lapp Insulator Co.

Pumps, Positive Displacement . . . . . . Unique TriRotor principle is described with colored cutaway drawings. Special features are detailed and points of superiority listed along with field of applications.
460A Yale & Towne Mfg. Co.

* From advertisement, this issue

For the latest developments in
Chemicals
Equipment
Processes
you'll find our "Guide To Technical Literature" right up your alley. You can get any bulletin or catalog in this listing . . . and fast. Simply circle the item's number on the Reader Service Post Card and mail.

LITERATURE . . .

Pumps, Process......Type Z4 APCO process pump is ideal for the handling of liquefied petroleum gases, refrigerants and other light non-viscous liquids. Latest design features. Full details in Bulletin 111-ZA.
T475 *Aurora Pump Div.

Pumps, Sanitary......Waukesha offers 18 new features: heavier shaft construction . . . Twin O-Ring Seal that positively prevents product leakage or intake of air . . . reversible sleeve to save shaft wear. 1957 Catalog.
212 *Waukesha Foundry Co.

Pumps, Vapor Purge . . . . . . Beach-Russ "Vapor Purge" pumps are designed to give highest efficiencies on moist circuits. Impossible for vapors to condense in the pump itself and impair its efficiency. Literature.
R469 *Beach-Russ Co.

Pumps, Vertical......Easy to use table for determining horsepower, capacity and head for vertical pumps makes new Bulletin 1100 worth keeping. Also contains sectional views, material specifications, schematic dwgs.
460B Layne & Bowler Pump Co.

Snubbers......Stops noise from intake and exhaust of air, etc., and stops pulsation caused by line surges from compressors, pumps, and blowers. Company offers complete literature on pulsation snubbers.
T476 *Burgess-Manning Co.

Vents . . . . . . Complete Venting Manual shows operating features and special applications of complete Protectoseal line. "In-line" vent avoids frequent, costly and highly dangerous roof-top inspection.
345a *Protectoseal Co.

Services, Processes, Misc.

Aerosols......Describes company's facilities for aerosol loading of cosmetics, pharmaceuticals and household specialties. Services include research and laboratory facilities; also, complete plant for processing and mixing.
460C Stalfort of Pa.

Design, Engineering & Fabrication......Company offers these advantages: on the spot technical advice, engineering design, highest quality materials and complete construction facilities. Request Bulletin CC No. 3.
354 *Atlas Mineral Prods. Co.

Doors, Quick Opening . . . . . . Struthers Wells quick opening doors furnish the means for complete automation . . . the results of advanced engineering achievements. For complete details, see Bulletin SW-553.
317 *Struthers Wells Corp.

Dyeing......Latest commercial formulas for dyeing, printing, finishing and heat treating fabrics of Arnel and Arnel blends. Formulas for efficient commercial operations are provided in 56 p. bulletin, TD-15A.
460D Celanese Corp. of America.

Epoxy Case Molds......4 p. describing newly developed system for making case molds from epoxy resins. Detailed mixing data, sealing and parting of the block mold, how to apply surface skin. Bulletin 17.
460E Smooth-On Mfg. Co.

Epoxy Casting......4 p. describing techniques involved in using epoxy resin compounds for casting. Of value to makers of models or patterns, vacuum forming molds, dies and potting of electrical components, TB 10.
460F Smooth-On Mfg. Co.

Fire Extinguishing Systems, Carbon Dioxide . . . . . . Features: all operating parts completely enclosed, no clumsy triggering methods or falling weights, self-contained, easy testing of all operating parts. Request booklet.
436 *Walter Kidde & Co.

* From advertisement, this issue

Grating & Stair Treads......Blaw-Knox electroforged steel grating makes every step a safe step indoors or outdoors. Makes available new reference & quotations. For more information request Bulletin 2486.
223 *Blaw-Knox Co.

Hydrodynamics....."Engineering the Unusual in Hydrodynamics" describes company's facilities and equipment by means of photographs of past commercial installations captioned by description of successful operation.
461A S. Morgan Smith Co.

Laboratory Equipment......30 p. pictures describes new and redesigned instruments and apparatus for laboratory use including electric incubators, portable Karl Fischer moisture determinator, vapor pressure apparatus.
461B Central Scientific Co.

Metal......24 p. brochure presents a profusely illustrated description of the operation of each company division, varied nature of its production, its basic philosophy. Called "Of Men and Metal."
461C Continental Copper & Steel.

Nuclear Power......25 p. detailing in picture and text the various phases of design work on the pioneer Commonwealth Edison Dresden nuclear power plant to be completed near Chicago by 1960.
461D General Electric Co.

Oil Industry......32 p. booklet aims at giving consumers of all petroleum products a realistic understanding of how the oil industry operates. Mostly text, it is told in terms of independent operators. Request your copy.
461E Gulf Oil Corp.

Plant Sites......Data on raw materials, transportation, power and fuel, markets, labor, facilities, sites, community services, laws and regulations, etc. Also includes physical map. "Industrial Location Services."
L455 *N. Y. State Dept. of Com.

Recruiting......24 p. outlines technical opportunities available at the company's research and development laboratories at Marcus Hook, Pa. Description of the work of sections and groups highlighted by text.
461F American Viscose Corp.

Research......First issue of quarterly bulletin which will report research activity on new chemicals or new applications for existing products. This one covers oleyl amines, alphasulfoalkyl acids, ethochemicals.
461G Armour & Co.

Research and Development, New Product......Key to developing successful new products is given in new brochure called "How to Develop Successful New Products." Full of case histories and do's and don'ts. Request your copy.
38 *Foster D. Snell, Inc.

Safety Equipment, Storage Tank......Company offers Safety Bulletin Series on "Flammable Liquids, their characteristics, hazards and safe handling." Includes: conservation type vents, tank openings, etc.
345-b *Protectoseal Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking

You can get any publication in this literature listing by cricling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

READER SERVICE . . .

PRODUCTS

• Your complex index to chemicals, materials, equipment and services, taken from this issue's advertisements, new products departments and "Guide to Technical Literature."

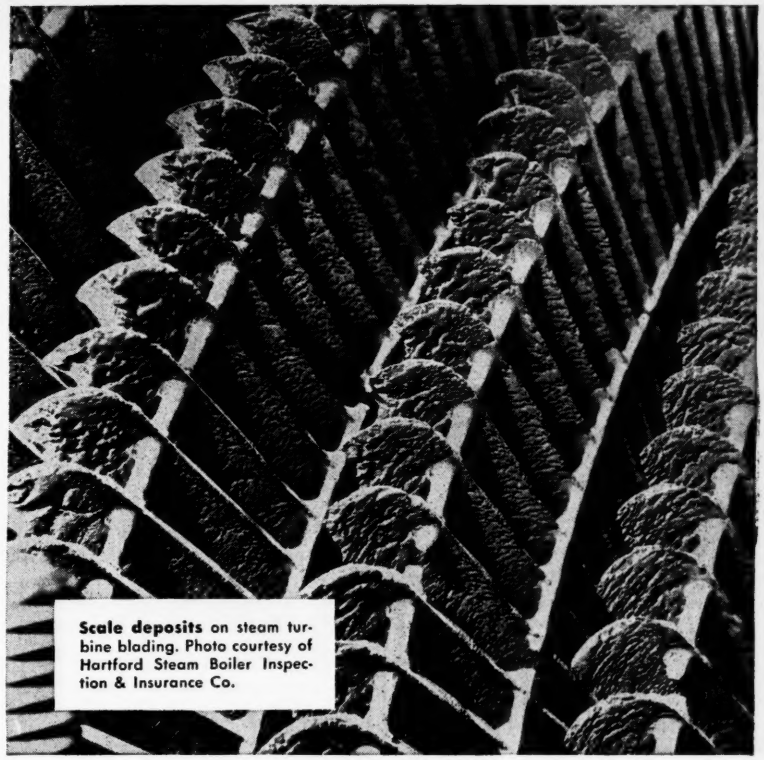
• Products listed feature code numbers which show the page on which they appear, L (left), R (right), T (top), B (bottom) indicate ad location; A, B, C, etc. and a, b, c, etc. identify specific product items on an editorial page or in an ad.

• You can get information on any listings by circling its key number on the Reader Service Postcard (see inside back cover). Replies will come direct from the companies manufacturing the products.

CHEMICALS

INDEX

C. J. ROHRBACH

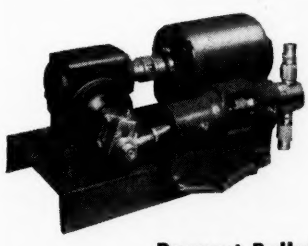


Scale deposits on steam turbine blading. Photo courtesy of Hartford Steam Boiler Inspection & Insurance Co.

No Build-Up! No Blow-Up!

... WHEN MODEL 1106 PROPORTIONEER FEEDS BOILER WATER CHEMICALS

Prevent scale build-up (caused by boiler carry-over) on turbine blades with proper raw water or internal steam boiler treatment. Model 1106 Proportioneer feeds all chemicals (alkaline, neutral, or acid) accurately (guaranteed within ±1%) over 15 to 1 range. Capacities range from 0.11 to 35.6 GPH . . . for discharge pressures up to 1100 psig.



PAY LESS, GET MORE!

Design features of this proportioning pump include interchangeable measuring cylinders, super-accurate Vane-Guide check valves, and percentage calibrated stroke-length scale.

Request Bulletin 1106-2 for complete data. Write to PROPORTIONEERS, INC., 369 Harris Avenue, Providence 1, Rhode Island.

PROPORTIONEERS, INC.
DIVISION OF
B-I-F INDUSTRIES
PROVIDENCE, RHODE ISLAND
METERS FEEDERS CONTROLS

PRODUCTS . . .

EQUIPMENT

PRODUCTS . . .

PRODUCTS . . .

PRODUCTS . . .

PRODUCTS . . .

PRODUCTS . . .

PRODUCTS . . .

PRODUCTS . . .

Services

READER SERVICE . . .

INDEX OF

Month after month you'll find industry's most progressive firms among our ad pages. Use this index to keep in touch with what they're offering that'll help you in your job.

A

B